Indiana University Purdue University – Fort Wayne

Department of Engineering

ECE 406

Capstone Senior Design Project

Report #2

Project Title:	HVAC Data Measurement and Acquisition Device	
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Date:	May 2, 2014	

ClimateMaster

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Lastly Donna for let us use her home and HVAC system for testing purposes and Pat from Geothermal Sales and Services for setting up the meeting with Donna to finalize our project.

Thank you all!

Abstract

Currently the startup of commercial and industrial Heating Ventilating and Air Conditioning (HVAC) systems require the physical presence of a technician to gather various data points required to confirm the equipment is running correctly. This is accomplished by the use of specialized hardware. Once the data is collected, the information is recorded using paper and pencil, which can be considered a rudimentary process. ClimateMaster has HVAC systems that need to be tested to ensure safe, reliable, and efficient cooling and heating operations. Some measurements must be acquired by hand; however it is possible for other values to be collected and recorded electronically. Electronic forms of entered data could be created using a handheld data collection device such as a laptop, smart phone, or tablet.

This project will attempt to eliminate the archaic method of paper and pencil and replace it with a new digital approach. This will save the technician time and physical resources.

Section I: Problem Statement

1. Problem Statement

ClimateMaster is the market leader in designing and manufacturing Geothermal Heating Ventilation and Air Conditioning systems. These systems require measurements, both physical and electrical, that are recorded to ensure proper mechanical functionality. The various measurements are currently recorded by hand and noted on a physical form. The HVAC system must be tested before turning over to the owner to ensure safe, reliable, and efficient operation in cooling and heating mode. The measurement procedure ensures that the system can properly cool and heat within desired time constraints. A majority of the measurements are still recorded manually by hand but, with advancements in technology, the values can now be recorded electronically.

It was proposed to create a method for the electronic submission of the test record which would be a fast and efficient use of production resources; thus enabling engineering and technical support to easily and quickly access the values that were recorded. Since the model, serial and part numbers are part of the submission, defective parts can easily be cataloged and searchable. Such a method would cut down on the physical time spent at the job site and ensure ease of access to data from each unit.

ClimateMaster would like a device that tests each unit in both heating and cooling mode to ensure proper mechanical operation and record necessary data to confirm satisfactory operation. This all should be done with minimal wires or connection to the unit. This new apparatus will be used by the technician performing the startup of each unit and may be further implemented into each unit manufactured in the future.

2. Requirements & Specifications

This system must be compatible with the pre-existing ClimateMaster unit and control board that will be supplied. Requirements must be met to achieve the following goals.

The device should:

- Run the unit to ensure mechanical operation in Test Mode, Cooling Mode, and Heating Mode..
- Record the temperatures and voltages given by the control board.
- Record the M# and S# of each unit.
- Record any data into an electronic form.
- Communicate without wires with an Android based device such as a phone or tablet.

3. Given Parameters and Adaptions

The device is to use a technology readily accessible on a phone or tablet in which to interconnect with wirelessly while maintaining a wired connection using the RS485 protocol that currently exists on the DXM2 control board.

Originally, WIFI was considered but the necessity of internet independence made it a difficult option. Also, a router would be needed with a power source further complicating the design (Ad-Hoc mode). Infrastructure mode was a more viable option but was not possible on the Arduino system.

Phones and tablets have Bluetooth transmitters installed for operation of several devices such as keyboards and headsets. A Bluetooth module was compatible and available to the Arduino system. There was more literature on Android to Android devices available so Android to Arduino was more of a challenge.

4. Design Variables

The final design concept, as well as more minor design details, is largely at the discretion of the design team. Variables to be considered are the basis in which the device must work within a minimum set standards.

- Microcontroller series: Arduino Mega series – 2560 or ADK
- Mobile device: Android based phone or tablet
- Data Transfer: RS485 as pre-existing standard; Bluetooth adapter to mobile device
- Software: Android version minimum – sets lowest standard for mobile device

Some earlier versions of Android are not as adaptable and for earlier devices must have code retro-programming from newer versions back to the older versions to use certain features. This is the basis in which a minimum Android version must have a standard as a design variable.

5. Limitations & Constraints

The limitations and constraints of the device were taken into account in order to properly design the apparatus for ClimateMaster. Limitations and constraints are anything that could be potentially inhibiting of the system. These were properly accounted for in order to adapt the system correctly. Listed below are the parameters that are limiting factors.

- Distance:
    - Device must be able to work within 0-20 feet from HVAC unit with line of sight usually
- Cost:
    - IPFW will be sponsoring this project, therefore final cost of the project must not exceed a budget of $400. It is important to keep tis in mind and design economically.
- Reliability:
    - The unit should work reliably as this will be the primary method for testing units and the technician will most likely not bring alone the old design.
- Voltage Range: Depends on the voltage source
    - 265V 60Hz single phase
    - 208-230V 60Hz single phase
    - 208-230V 60Hz 3 phase
    - 460V 60Hz 3 phase

Section II: Subassembly Designs

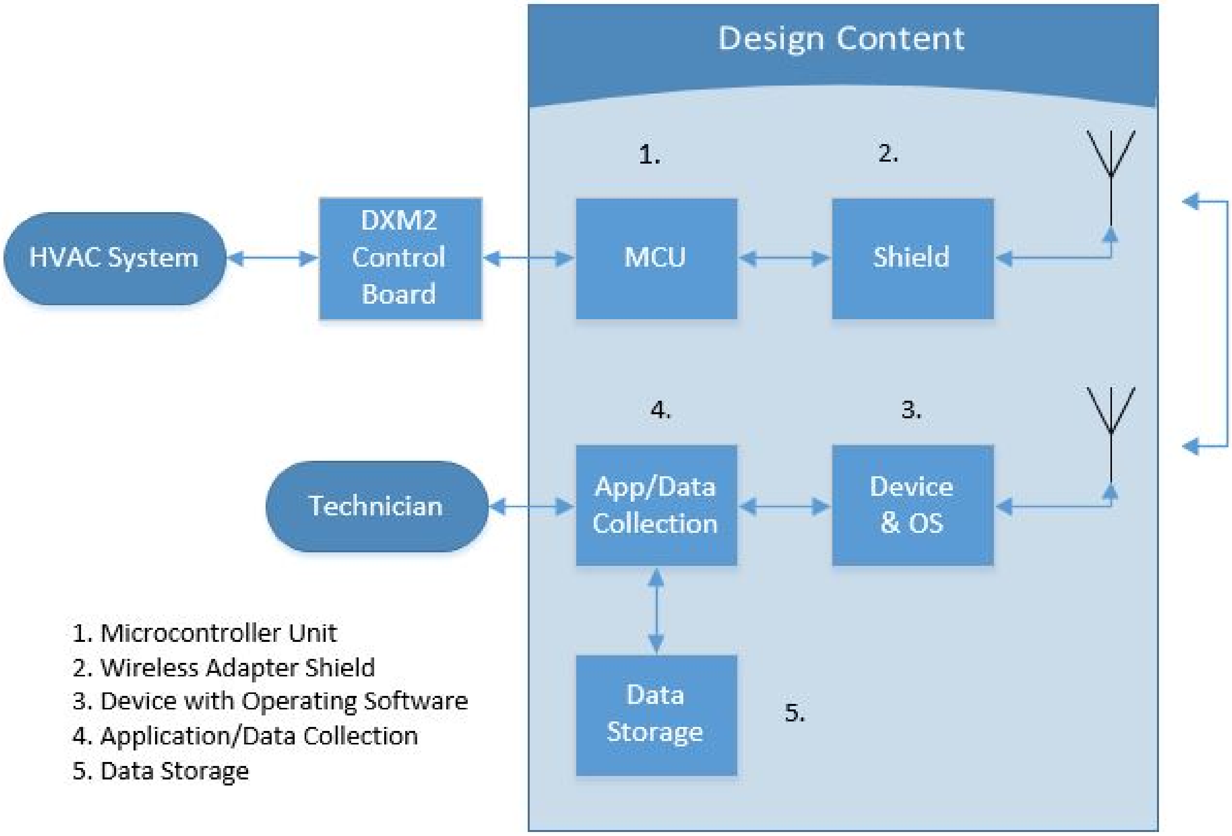


Figure 1: HVAC Design Content to be determined.

The area highlighted is what is to be contained in the device for test verification. The Microcontroller Unit (1.) and Wireless Adapter (2.) are the physical parts of the device but do not show additional parts used such as Max485 and solid-state relay modules. This section collects data from the control board via RS485 and relays. It also accepts commands from the technician and processes them to access the control board.

The lower set of items are Device & OS (3.), Application/Data Collection (4.) and Data Storage (5.), these items belong on the technician side and are specifically the following: an Android device with Android operating system, an application created to control the unit using Eclipse as the Android development environment, an electronically generated form with Data sent from the DXM2 board to the Arduino, which later sends it to the Android, which converts this data into PDF, finally a micro SD card that will be used to store all of the generated PDF forms.

1. Component Design

a. Solid State Relay

The project needed a component that could switch the electrical line on and off (Line R coming from the DXM2). A relay is a device that provides an electrical connection between two or more points in response to a control signal. In addition, it has full isolation between the control signal and the control board (DXM2). A solid state relay (SSR) was used for switching on/off. A SSR is an electric switching device in which a small control signal controls a larger voltage. It serves the same function as an electromechanical relay, but it is smaller, faster, and has no moving parts when switching.

Omron's G#VM-61A1 is MOS FET relay compact solid state relay with dielectric strength of 2.5kVAC between I/O using optical isolation (LED). It is rated up to 50mA at 60VAC, so it can handle the AC voltage that is coming from the DXM2 which is 24VAC. The control signal is rated at 5V DC and requires at least 50 mA. **Figure 2** shows the relay as well as its schematic. Pins 1 and 2 are the control LED terminals, pin 3 and 4 are the switching connections. Pin 3 is connected to the load (Fan, Reversing Valve, or Compressor) and pin 4 is connected to the 24VAC (R from the DXM2).

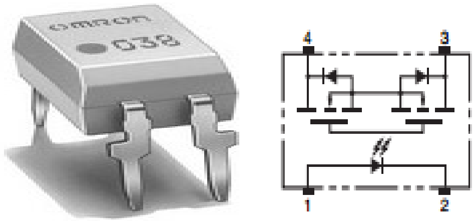


Figure 2: Solid State Relay with schematic.

b. Bluetooth Shield

Next, the project required a change of the WIFI shield to a Bluetooth module due to lack of point access of internet network in the premises. Therefore, a Bluetooth module became an excellent choice in order to communicate with the DXM2 board. Hence, for the project the DF-Bluetooth V3 module was chosen due to its low cost and matched specifications for the communication.

DF-BluetoothV3 Bluetooth module uses a unique double-board design aims to prevent electrostatic damage to the module. It is designed to have 2 DC power input, wide voltage supply (3.5V ~ 8V) and 3.3V power supply, suitable for various applications. STATE LINK is indicated by a clear and bright LED which is used to display module status and connection status (STATE state: Search state (high 104ms 342ms 2.9Hz cycle flicker) connection status (high 104ms period 2s 0.5Hz flashing), LINK state: paired). It has built-in on-board antenna which provides high quality signals.

Specifications

- The Bluetooth chip: CSR BC417143
- Bluetooth protocol: Bluetooth Specification v2.0 + EDR
- USB Protocol: USB v1.1/2.0
- Operating frequency: 2.4 ~ 2.48GHz unlicensed ISM band
- Modulation: GFSK (Gaussian Frequency Shift Keying)
- Transmit Power: ≤ 4dBm, Class 2
- Transmission distance: 20 ~ 30m in free space
- Sensitivity: ≤-84dBm at 0.1% BER
- Transfer rate: Asynchronous: 2.1Mbps (Max) / 160 kbps; Synchronous: 1Mbps/1Mbps
- Safety features: Authentication and encryption
- Support profiles: Bluetooth serial port
- Serial port baud rate: 4800 ~ 1382400 / N / 8 / 1 default: 9600
- LED indicator: STATE: Search state (high 104ms 342ms 2.9Hz cycle flicker) connection status (high 104ms cycle 2s 0.5Hz flashing), LINK Status: Always after match
- Input Voltage: +3.5 V ~ +8 V DC and 3.3V DC/50mA
- Working temperature: -20 ℃ ~ +55 ℃
- Module Size: 40 × 20 × 13mm

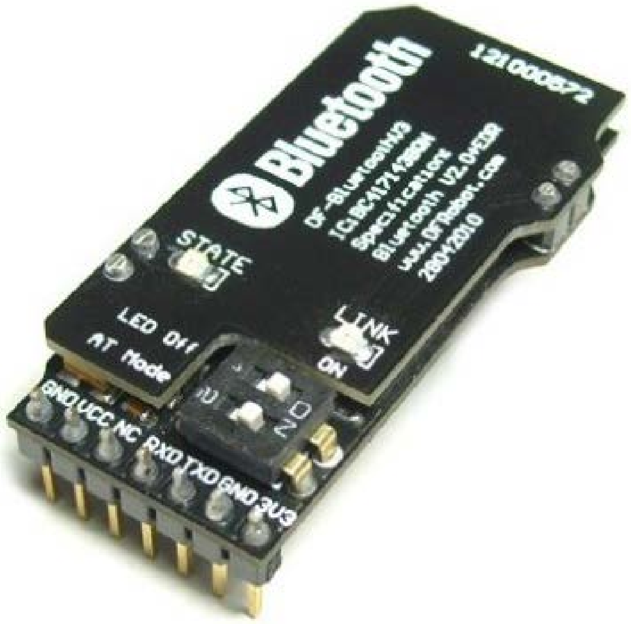


Figure 3: DF-Bluetooth V3 module.

c. MAX485

In order to interface the control board (DXM2) of the HVAC with the Microcontroller unit (MCU) a MAX485 is necessarily required to achieve a half-duplex communication between the two boards. Additionally, the DXM2 features a RS485 chip mounted on its board.

The MAX485 is low-power transceiver for RS-485 and RS-422 communication. Each part contains one driver and one receiver. It features a reduced slew-rate driver that minimize EMI and reduces reflections caused by improperly terminated cables, thus allowing error-free data transmission up to 250kbps. The driver slew rates on the MAX485 are not limited allowing them to transmit up to 2.5Mbps.

The module interfaces an Arduino with the control board (DXM2) to RS-485. RS485 is used for Serial Communications over longer distances than direct RS232 or TTL, and supports multiple units on the same bus (Multi-Drop).

- Multiple Units can be connected to the same RS-485 wiring.
- All Chip pins are brought out for proper controls
- Working voltage: 5V
- Board size: 44 (mm) x14 (mm)

Figure 4 shows the connections of the MAX 485. Pin RO is the receiver or RX which acquire data from the Arduino board connected to pin RX0. Pin DI is the transmitter or TX which is connected to TX0 on the Arduino. Pin DE is driver enable or control enable that set what board is a master/slave. If DE is high, it sets the Arduino as master, allowing the Arduino to transmit data to the DXM2 board. If DE is low it sets the Arduino as slave allowing the DXM2 to act as master which is transmitting data to the Arduino. Pins A and B of the DMX2 are connected to the pins A and B of the MAX485 module, respectively which allow data to flow from the DXM2 to the MAX485, and then data will flow from MAX485 to Arduino through pin RO, receiver output.

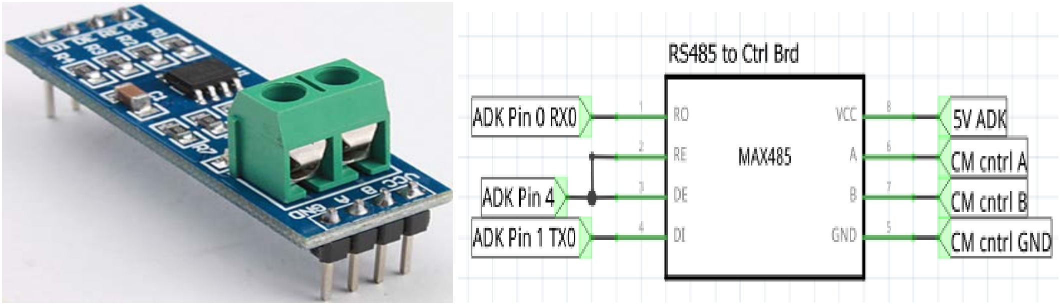


Figure 4: Max485 module.

d. Arduino Mega ADK Microcontroller

Based on the Atmega2560, the Arduino Mega ADK is a compatible board. Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It has a USB host interface to connect with Android based phones. In addition, it has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Furthermore, In addition, some pins have specialized functions:

Serial: 0 (RX) and 1 (TX)
Serial 1: 19 (RX) and 18 (TX)

Serial 2: 17 (RX) and 16 (TX)
Serial 3: 15 (RX) and 14 (TX).

Specifications

Operating voltage	5V
Input voltage	7V
Digital I/O pins	54(of which 15 provide PWM output)
Analog Input Pins	16
DC current per I/O pin	40mA
DC current for 3.3V pin	50mA
Flash memory	256KB of which 8KB used by bootloader
SRAM	8KB
EEPROM	4KB
Clock speed	16MHz
USB host chip	MAX3421E

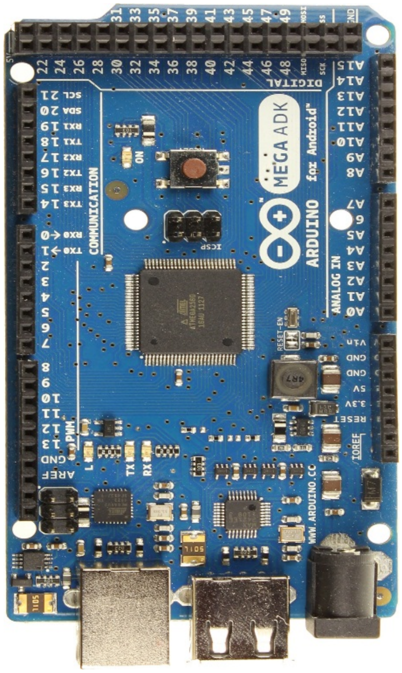


Figure 5: Arduino Mega ADK.

2. Software Development

a. Establishing Initial Communication

Initiating communication between the Android device and the Arduino microcontroller is the most essential function so it should be done first. Originally, WIFI was the desired concept due to officially branded WIFI shield by Arduino. The WIFI shield as its support has certain shortcomings that were undesirable to the needed criteria. There were adaptions but were excessive and costly. As a result, Bluetooth was used as nearly all current phones and tablets come with Bluetooth for hands free talking or keyboards (for tablets).

The WIFI technology on Arduino became a short coming in that it does not support WIFI Direct. Android 4+ supports the technology but there is documentation with other Android based devices. WIFI Direct enables the ability to directly connect through Infrastructure Mode where no access point is needed. Unfortunately, the Arduino WIFI shield is programmed to be routed through an AP, or access point, such as a router. Its main function is for internet connectivity. This project is not using the internet for a variety of reasons including that the facility may not have internet or access points available. Thus the design would need to facilitate this requirement with adding a router which can become expensive and complicated.

Two separate attempts were made to make a Bluetooth connection, a selectable device prompt on the Android device and hardcoding the MAC address.

The device select prompt was based on the Bluetooth Chat Android example which contained several ".jar" files that interacted. Very little programming notes were available to understand the interaction between the files and screen "Activities." The adaptation was successful in finding the Bluetooth module attached to the Arduino but was unsuccessful in connecting due to permission requirements. The computer science programmer was unable to assist in a resolution.

The method of using sample code on the internet was more successful. The code was all inside a single ".jar" file. A demonstration that the communication was successful was performed using several different color LEDs.

b. Android - Arduino Flow Chart

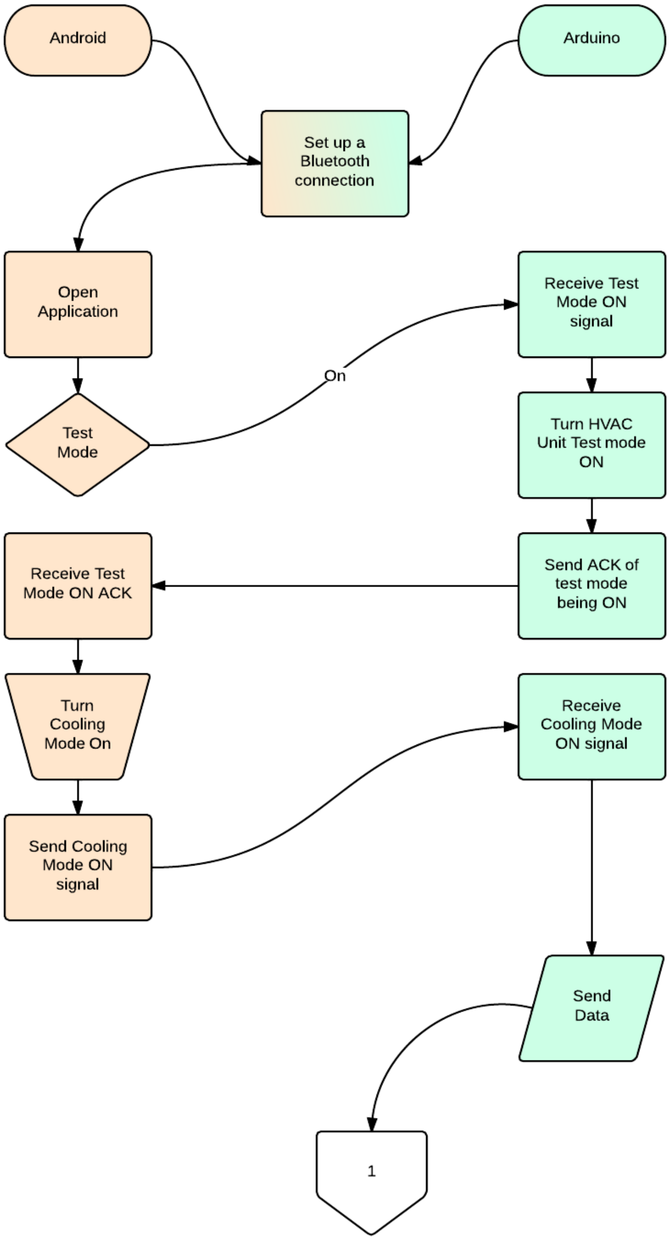

Android
Arduino
Set up a Bluetooth connection
Open Application
Receive Test Mode ON signal
On
Test Mode
Turn HVAC Unit Test mode ON
Receive Test Mode ON ACK
Send ACK of test mode being ON
Turn Cooling Mode On
Receive Cooling Mode ON signal
Send Cooling Mode ON signal
Send Data
1

Figure 6a: Android Arduino Flow Chart.

Initialization and Cooling Mode.

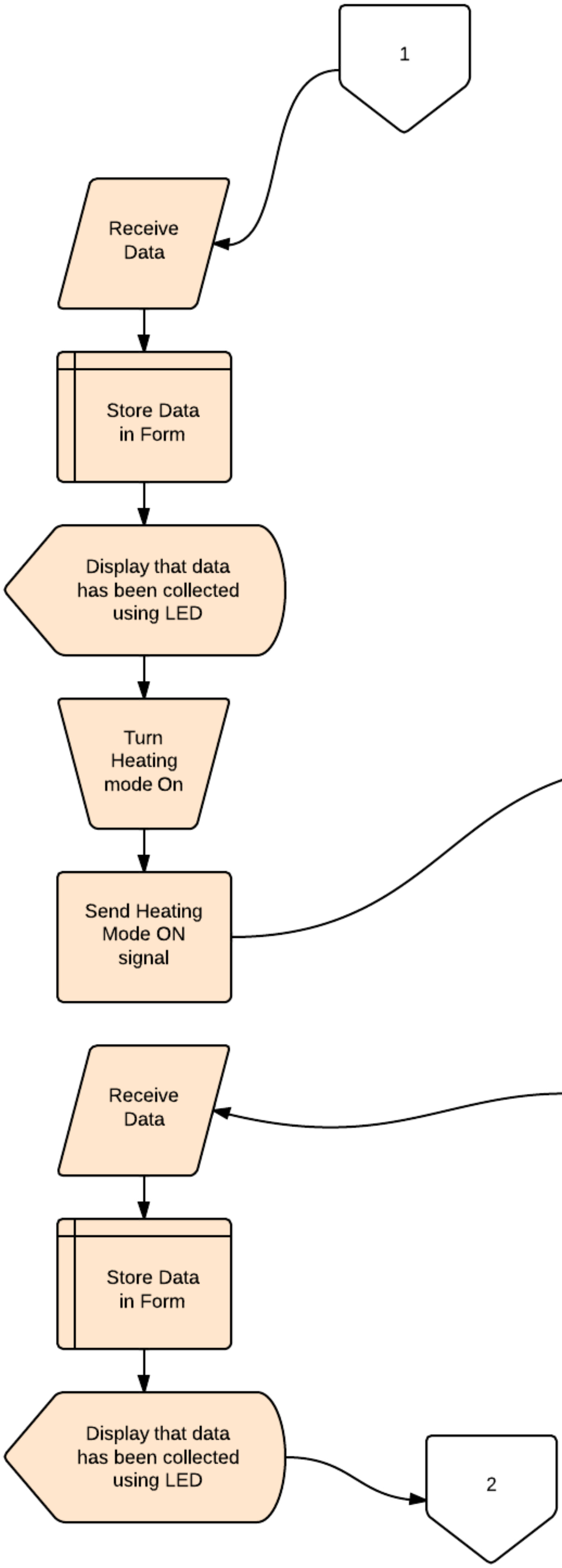

1
Receive Data
Store Data in Form
Display that data has been collected using LED
Turn Heating mode On
Send Heating Mode ON signal
Receive Heating Mode ON signal
Send Data
Receive Data
Store Data in Form
Display that data has been collected using LED
2

Figure 6b: Android Arduino Flow Chart.

Heating Mode and Data Population.

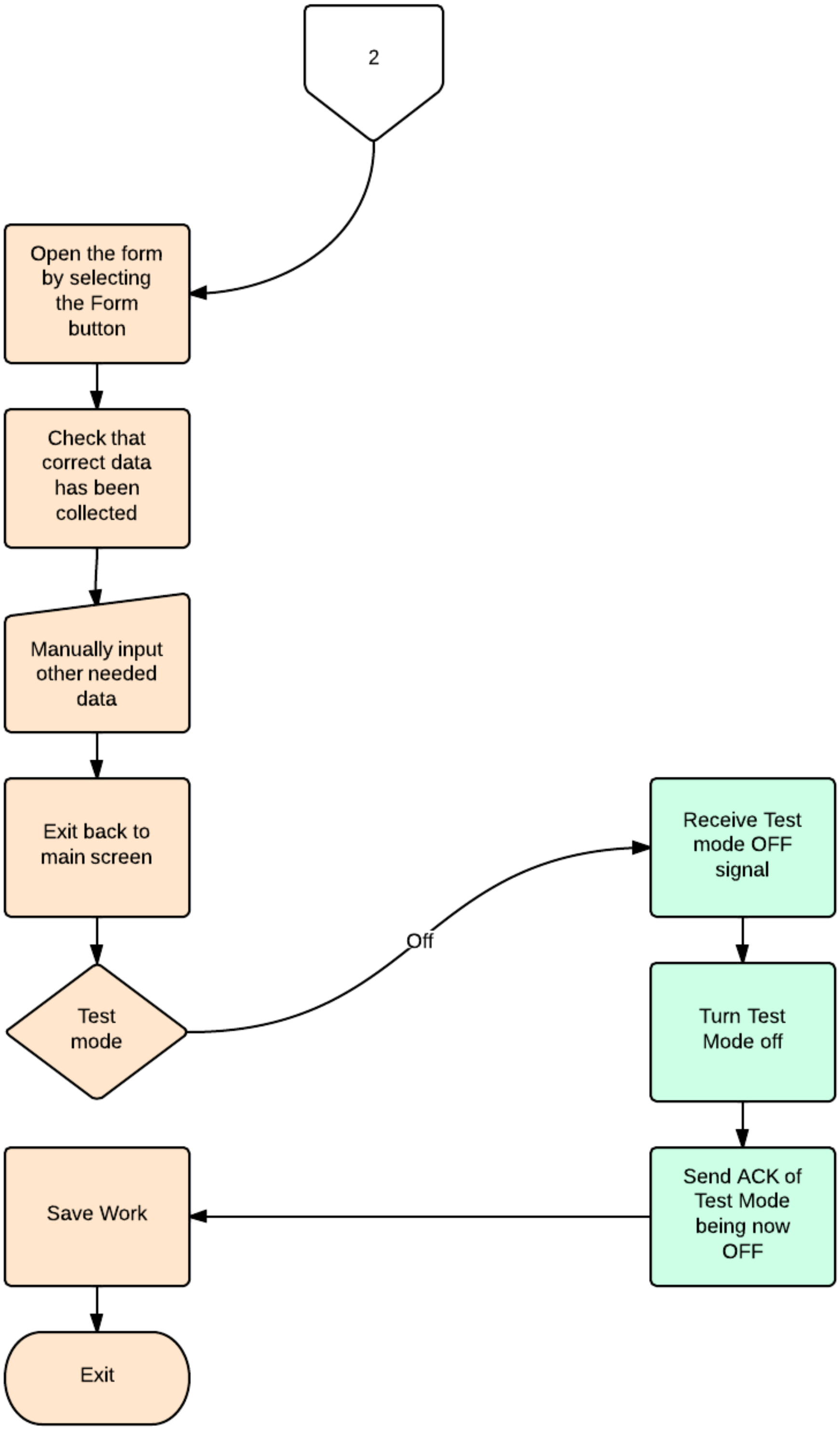

2
Open the form by selecting the Form button
Check that correct data has been collected
Manually input other needed data
Exit back to main screen
Test mode
Off
Receive Test mode OFF signal
Turn Test Mode off
Send ACK of Test Mode being now OFF
Save Work
Exit

Figure 6c: Android Arduino Flow Chart.

Form Verification and Disconnection.

c. Procedure for Software Development

The explain the software development it is important to know that this project's software implementation was divided into two main sections, the Arduino section and the Android section, as shown in the two different columns in the Flowcharts from **Figures 6a**, **6b**, and **6c**.

Arduino:

In the Arduino code or sketch, there are two important parts that interface with the DXM2 and the Android application.

Controlling the Board

The first part is to engage in test mode by using Serial1 port (TX1 and RX1) via Bluetooth. By sending a letter "T" from the Android application via Bluetooth to the Arduino, a command called digitalWrite sets the pin high in order to turn on the relay for the Fan. Eventually, such operation is repeated for the other components (Compressor Y1 and the Reversing Valve). This operation is timed in the code in such a way that it matched the routine done by the technician manually on the job site.

RS485 Communication

The second part is dedicated to request information from the DXM2 through the MAX485. Similarly, the communication between the Arduino and the DXM2 is done using the Serial port (TX0 and RX0). The data rate or the baud rate is set to be 9600 bit /s. In the same fashion, a variable is sent from the Android application to the Arduino via Bluetooth to request a specific data from the DXM2.

Depending on which button has been pressed, a different, unique data packet is sent using the Serial.write command. If the data packet is valid, the DXM2 will recognize it and respond with another data packet, which will be read by the Arduino program using the Serial.read command. The Arduino will read the incoming response packet byte by byte, and will assign different names to the bytes that contain the important information which will undergo a concatenation process and then will be print out using the Serial.print command to the Android side which will be explain in more detail next.

Android:

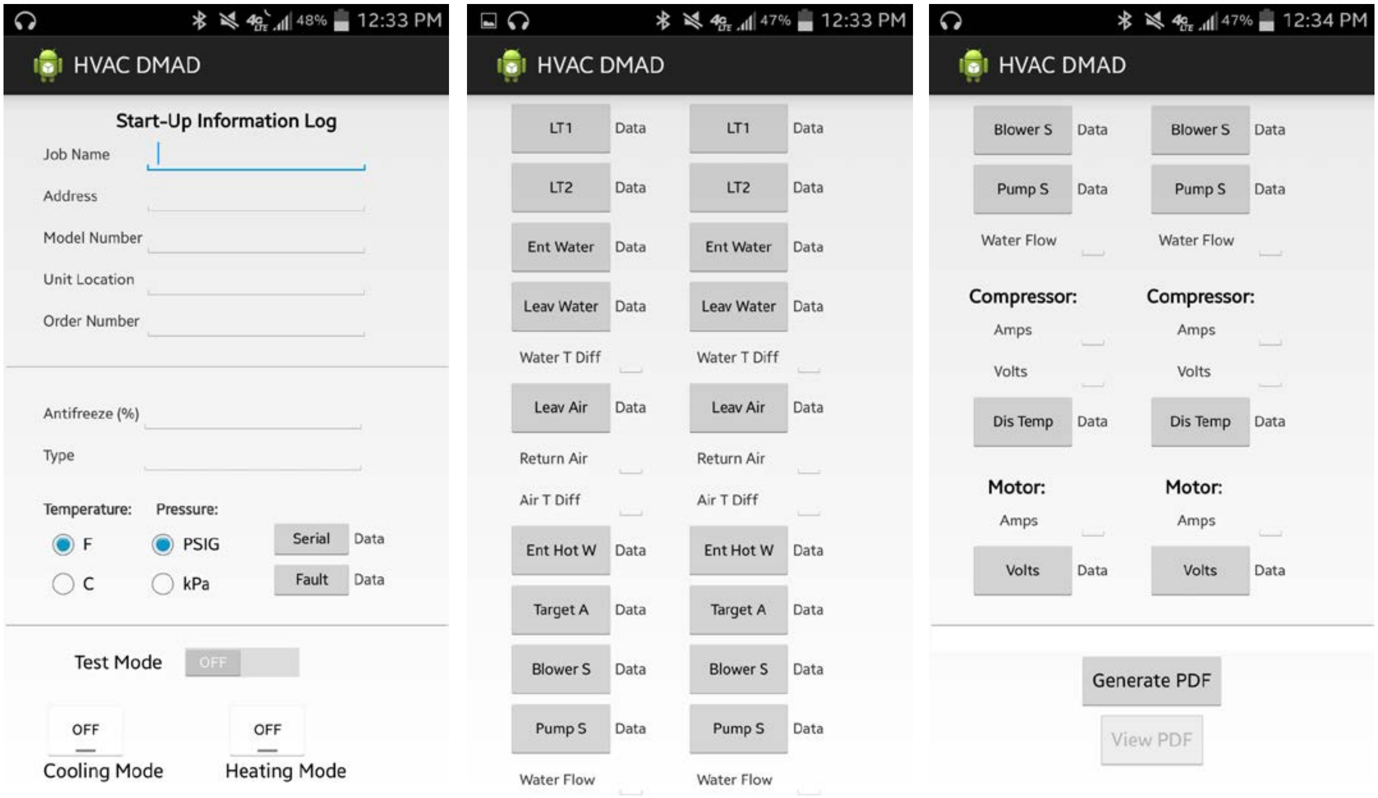
To be able to work with Android it was essential to connect via Bluetooth with the chosen Bluetooth shield using Android's official Bluetooth API. There are four major tasks necessary to be able to get connectivity with Bluetooth: setting up Bluetooth, finding devices that are either paired or available in the local area, connecting devices, and transferring data between devices. The BluetoothAdapter class was used in the Android code since it represents the local Bluetooth radio on the phone. It performs fundamental Bluetooth tasks, such as initiate device discovery, query a list of paired devices, instantiate a device using a known MAC address, and create a server socket to listen for communications from other devices. The BluetoothSocket class is used to both initiate an outgoing connection and to manage the connection. Since the Bluetooth stack uses the Service Discovery Protocol (SDP) to gather information about the devices and its parameters, the UUID (Universally Unique Identifier) was chosen for our connection. Once the socket is connected, data can be exchanged with another Bluetooth device via InputStream and OutputStream objects which read and send data in bytes. This allows the application to send and receive data serially via the RFCOMM Bluetooth layer.

Once Bluetooth has been established, the Android development process can begin. An example code for and Android application was found in the research phase of this project and used to start developing this app. The found code was used to turn on and off an LED through Bluetooth using an Arduino microcontroller (such code was completely adapted for our purposes). Now, the process of developing our application is divided in three main subsections.

Sending Control Bytes to Arduino

The Android Application was created so that every time a control button has been pressed, a specific byte is sent over Bluetooth to the Arduino, the Arduino will recognize a valid byte and perform whichever specific function it is designed to perform. If we continue with the Test Mode example, the Test Mode switch (once switched ON) will send a 'T' byte over Bluetooth to the Arduino, the Arduino will read this byte through a variable called incomingByte and if it is a 'T' it will go through the test mode procedure which consist on turning on and off the Fan three times and leaving it on.

The Android Application that was created consisted on 30 simple buttons (28 for data and 2 for PDF), 2 toggle buttons (cooling and heating mode), 1 switch (test mode), 4 radio buttons (temperature and pressure), and 23 text fields, these are all illustrated in **Figure 7**. All of the simple buttons, toggle buttons, and the switch send control bytes as explained.



Temperature: ● F ○ C

Pressure: ● PSIG ○ kPa

Test Mode OFF

Cooling Mode OFF

Heating Mode OFF

Figure 7: Screen shots of the developed application for Android devices.

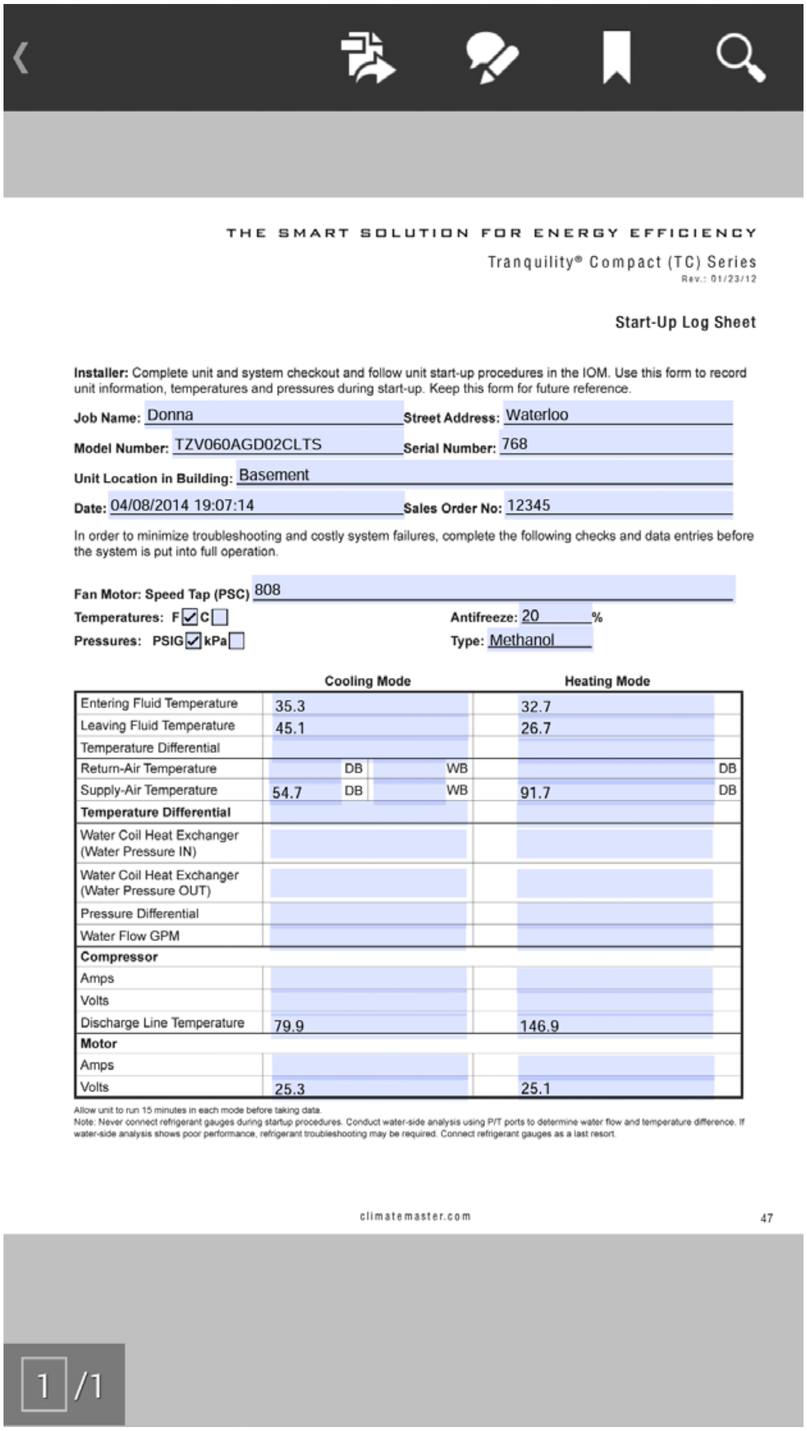
Receiving Data from Arduino

Once the Arduino has collected all the data from the DXM2 board via RS485 protocol, all of the bytes that contained data are sent to the Android using the Serial.print command in the Arduino code. This data will be received in the Android and will be assigned to a text field, specifically the text field next to the button that has been pressed. So if the Leav Water button is pressed, the data for the leaving water temperature will be sent to the Android, and assigned to the Data textview field next to such button. The same process applies to every Data button in the application.

Generating PDF

Next is to generate a pdf form where the technician will able to save the data acquired from the test mode. This procedure is achieved successfully by utilizing the three main classes from the itextpdf which are itextpdf.text.pdf.AcroFields, itextpdf.text.pdf.PdfReader, and itextpdf.text.pdf.pdfStramper. These three class are the key to generate a pdf form that will all of the collected data acquired from the DXM2 control board. But, first it was crucial to generate unique fields in the mentioned form using a program like Adobe Acrobat. Each create field will have a unique name, then the name of each field will be matched with the name of the data texview field in the android application. This matching will allow for the data to go to the correct spot in the form. Two other buttons where created to Generate a PDF and to View a PDF, the second button will only be available if the PDF has been successfully created, and will stay greyed out if there was a problem that stopped the creation of the PDF.

Once the PDF has been created and the View PDF button pressed, the android device will ask for the user to pick the program in which they wish to view the PDF. Our team picked Adobe Reader since it is a free program that can be downloaded in any Android device but also gives extra benefits such as it allows the user to select any field and edit it as desired within the Adobe Reader application without the need of going back to the HVAC DMAD application. **Figure 8** shows s screenshot of how the PDF will look in the Android device when is being viewed using Adobe Reader.



THE SMART SOLUTION FOR ENERGY EFFICIENCY

Tranquility® Compact (TC) Series
Rev.: 01/23/12

Start-Up Log Sheet

Installer: Complete unit and system checkout and follow unit start-up procedures in the IOM. Use this form to record unit information, temperatures and pressures during start-up. Keep this form for future reference.

Job Name: Donna **Street Address:** Waterloo

Model Number: TZV060AGD02CLTS **Serial Number:** 768

Unit Location in Building: Basement

Date: 04/08/2014 19:07:14 **Sales Order No:** 12345

In order to minimize troubleshooting and costly system failures, complete the following checks and data entries before the system is put into full operation.

Fan Motor: Speed Tap (PSC) 808

Temperatures: F ☑ C □ **Antifreeze:** 20 %

Pressures: PSIG ☑ kPa □ **Type:** Methanol

	Cooling Mode		Heating Mode
Entering Fluid Temperature	35.3		32.7
Leaving Fluid Temperature	45.1		26.7
Temperature Differential			
Return-Air Temperature	DB	WB	DB
Supply-Air Temperature	54.7 DB	WB	91.7 DB
Temperature Differential			
Water Coil Heat Exchanger (Water Pressure IN)			
Water Coil Heat Exchanger (Water Pressure OUT)			
Pressure Differential			
Water Flow GPM			
Compressor			
Amps			
Volts			
Discharge Line Temperature	79.9		146.9
Motor			
Amps			
Volts	25.3		25.1

Allow unit to run 15 minutes in each mode before taking data.
Note: Never connect refrigerant gauges during startup procedures. Conduct water-side analysis using P/T ports to determine water flow and temperature difference. If water-side analysis shows poor performance, refrigerant troubleshooting may be required. Connect refrigerant gauges as a last resort.

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Figure 8: Screenshot of a ClimateMaster's Start-Up Log Sheet that has been automatically filled out. The Blue fields are fields that can be edited within the Adobe Reader application.

Section III: Testing and Evaluation

Enclosure Assembly

The enclosure was chosen because the container contained a retained o-ring for waterproof capability. This is important because, should there be a water or coolant leak in the heat pump at the site, the test device would not be affected. The box had molded standoffs in it for mounting devices, but were too close to the wall to be effective. A Dremel rotary tool was used to cut out the pre-existing standoffs and white standoffs were super-glued into position for mounting the Arduino and Max485. Standard computer screws (4-32s) were used to fasten the boards into place.

For mounting the Max485, two female headers (4 pin) were soldered through a hole of Plexi-glass to 22 AWG wires. The wires were to be connected to the Arduino board to enable RS485 communication. The other side has wires that enable the RS485 communication to interface with the DXM2 communication pins.

The standoffs for the Arduino were set in corresponding locations with the pre-set holes on the Arduino. Not all holes were capable of having screws installed due to the proximity of the female headers used to attach wires for the pins.

Four standoffs and three screws secure the Arduino in place. The relay shield sits on top of the Arduino matching to the pass through pins on the shield. Power is passed from the Arduino to the relay shield in this way. Jumpers are connected to allow digital communications to the relays and Bluetooth adapter.

Three through holes were drilled into one side of the enclosure. This allowed RS485 and 24VAC wires to be accessed outside the enclosure. The third hole was for an off and on toggle (STSP) switch to be installed. Inside the enclosure, a 9 volt battery connector was soldered to one pin of the switch then to a common male power connector that fits to the female power connector to the Arduino. The other pin was from the ground side of the male power connector to the other pin on the switch.

The 9 volt battery is capable of sliding under the wires routed from the Arduino to the outside of the enclosure ensuring physical security and easy access for when the battery needs replaced.

Everything is contained inside the enclosure. The enclosure has enough room for heat dissipation without the need for active cooling through a fan. Once the wires are set to the desired length, the two holes containing the 24VAC and RS485 wires can be filled in with a flexible bond and allowed to air cure. The cure time is dependent on the type of bond used to fill the holes.

Component Integration

Figure 9 shows the system schematic diagram. The layout of the hardware consists of interfacing the Arduino with the DXM2 via the SSR relays. There are three relays that are associated with three components. The Fan (pin G) connected to the control signal pin 13 on the Arduino. The compressor in stage one (pin Y1) connected to the control signal pin 12 on the Arduino. The reversing valve (pin O) connected to the control signal pin 11 on the Arduino. The BluetoothV3 is intended for monitoring the test mode wirelessly by acquiring different data collected by the DXM2 board.

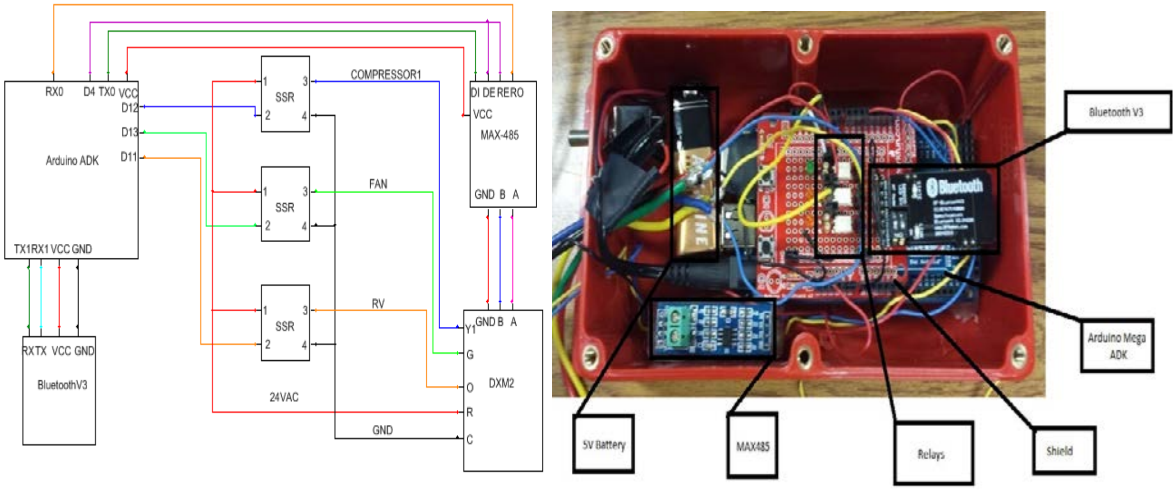


Figure 9: Hardware schematic diagram and fully integrated.

Integration and Test Results

Figure 10 describes the project fully integrated including the DXM2, the control board of the HVAC unit, and the switch box (**Figure 11**). The switch box consists of interacting with DXM2 board in order to simulate different components (Fan, compressor, LT1, LT2…). The switch box simulates an operating unit in the field. Different resistances simulate temperatures and voltages the device would see on an actual unit. It also allowed for a quick way to step down the voltage from the outlet to the 24 VAC the board requires to run. This normally would be down at the power contactor inside the unit.

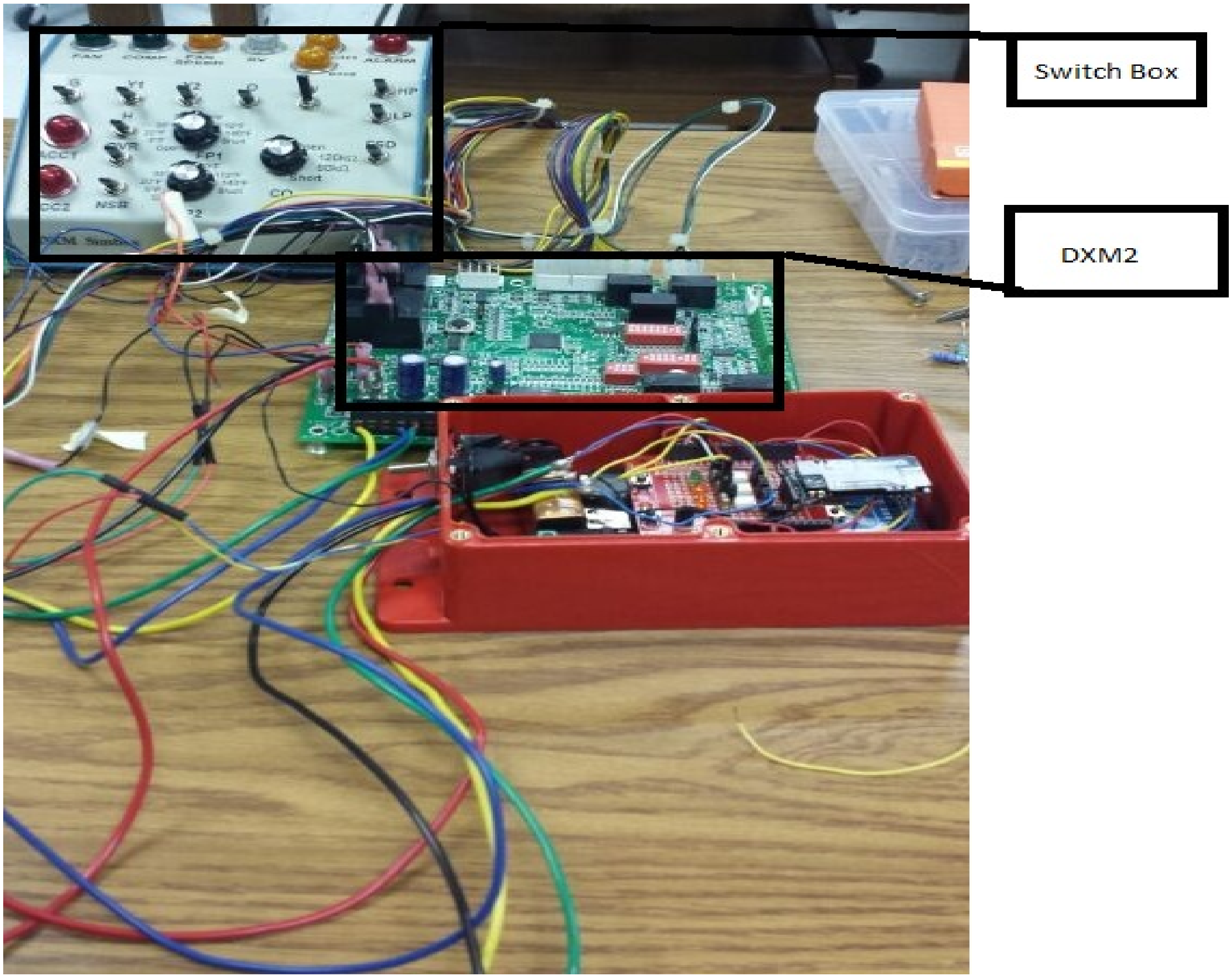


Figure 10: Hardware fully integrated.

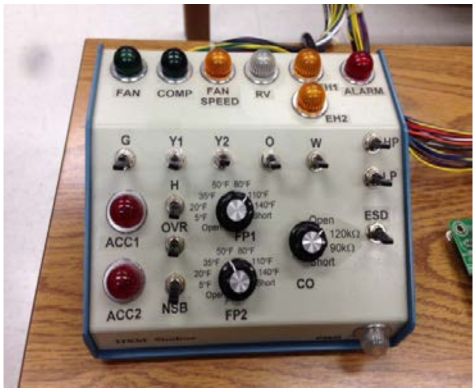


Figure 11: Switch box.

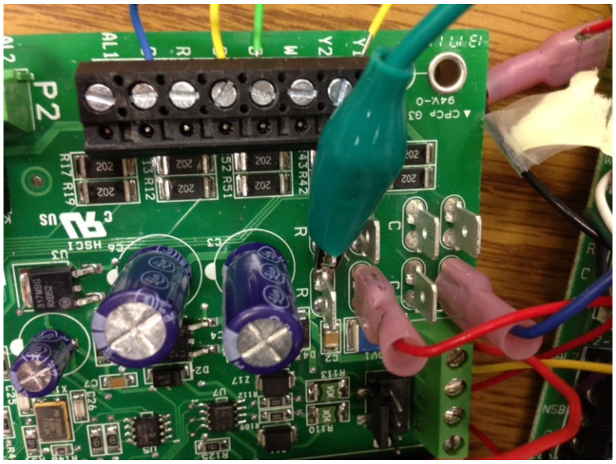


Figure 12: Example of G, Y1, O, R and Power IN (R) connections on the DXM2 Board.

Test Plan

The test plan was to interface the relay with DXM2 board for different components with the Arduino and the shield. The shield has the three relays plus the Bluetooth module.

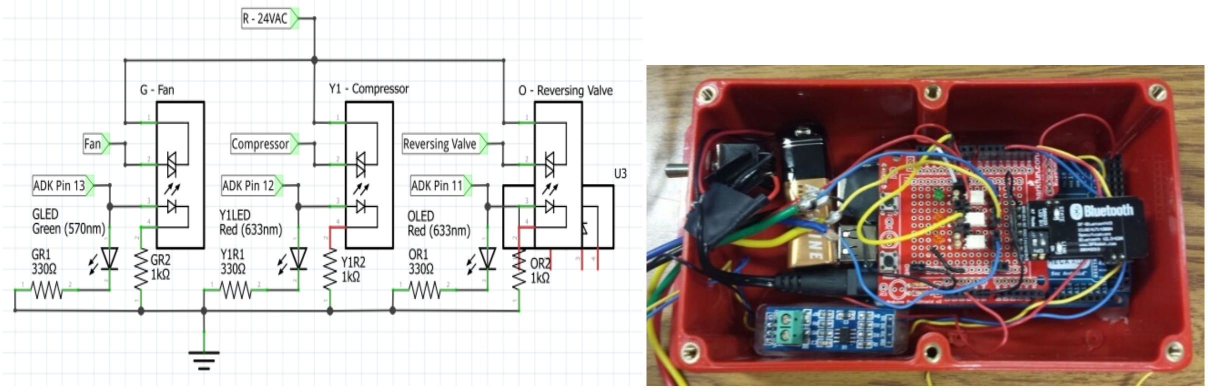


Figure 13: Relays schematic left: fully integrated on the shield right.

Once this set up was verified to be working correctly using the switch box, interfacing was done between the Bluetooth and the microcontroller. This step consists of engaging in the test mode which is cycling on/off the Fan 3 times in succession. Then once the unit is in test mode you can run the Fan, Compressor in stage 1, and the reversing valve, using the Arduino via Bluetooth. This step was successful and **Figure 17** shows the functionality of the relays using MyDAQ oscilloscope.

With the communication between Arduino and Android complete, the idea of turning on LEDs allowed the ability for the Arduino to activate a photo diode and turn on a MOSFET via photo-voltaic diode on its base.

The first part was to connect the relay and understand the built in package. From the schematic of the relay, it shows a resistor on the photo diode but does not show if it is inside. The resistor was assumed to be inside the package. The first relay burned. The next relay used had a 1kΩ at the base of the photo diode. **Figures 14**, **15**, **16**, and **17** below show using a MyDAQ for additional data acquisition of waveforms with voltages at MOSFET cutoff, activation, and saturation.

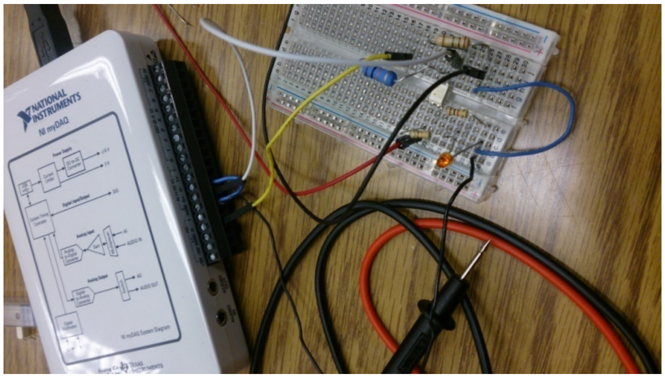
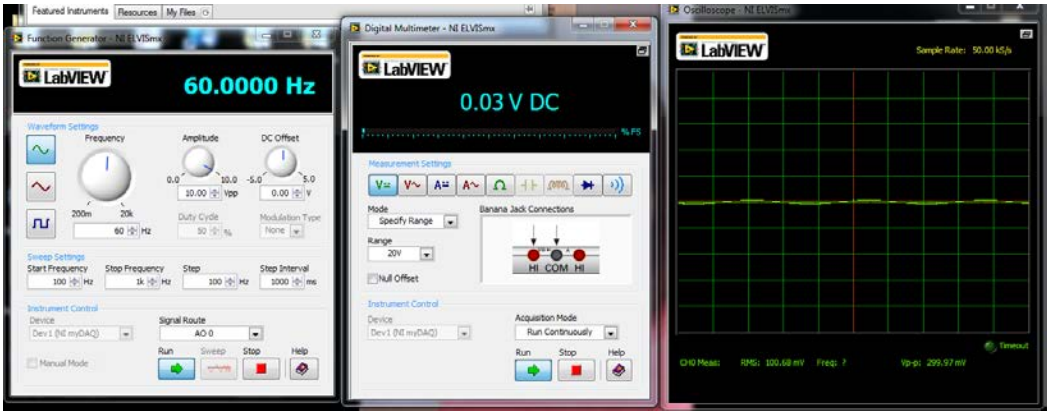


Figure 14: A relay set up using MyDAQ at cutoff.



Function Generator - NI ELVISmx

60.0000 Hz

Waveform Settings

Frequency: 60 Hz (200m – 20k)

Amplitude: 10.00 Vpp (0.0 – 10.0)

DC Offset: 0.00 V (-5.0 – 5.0)

Duty Cycle: 50 %

Modulation Type: None

Sweep Settings

Start Frequency: 100 Hz

Stop Frequency: 1k Hz

Step: 100 Hz

Step Interval: 1000 ms

Instrument Control

Device: Dev1 (NI myDAQ)

Signal Route: AO 0

□ Manual Mode

Digital Multimeter - NI ELVISmx

0.03 V DC

% FS

Measurement Settings

Mode: Specify Range

Range: 20V

□ Null Offset

Banana Jack Connections

Instrument Control

Device: Dev1 (NI myDAQ)

Acquisition Mode: Run Continuously

Oscilloscope - NI ELVISmx

Sample Rate: 50.00 kS/s

CH0 Meas: RMS: 100.68 mV Freq: ? Vp-p: 299.97 mV

Timeout

Figure 15: Frequency on MOSFET with photo diode bias at cutoff.

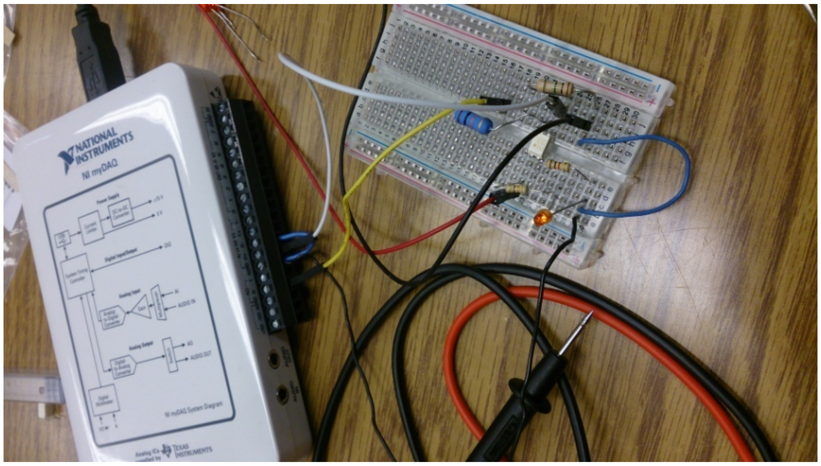
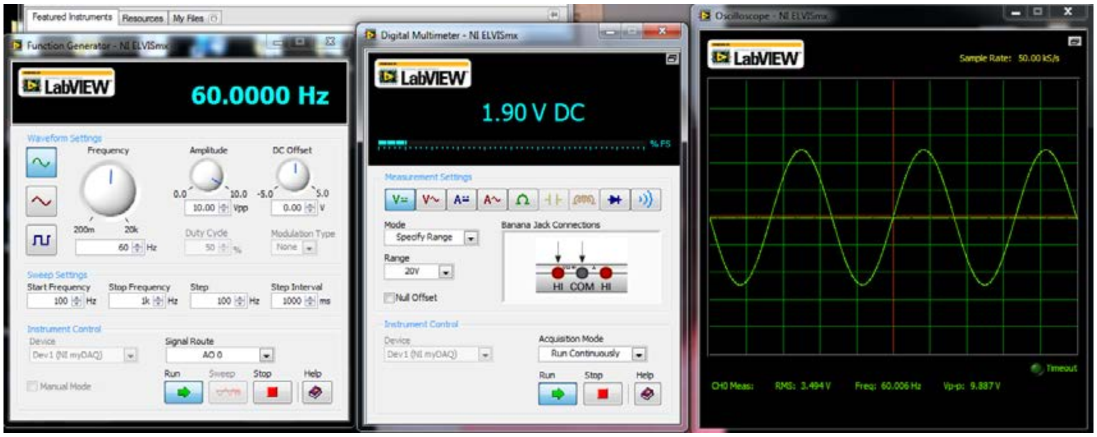


Figure 16: Photo diode at MOSFET biased. AC now conducting.



Function Generator - NI ELVISmx

60.0000 Hz

Waveform Settings

Frequency 60 Hz

Amplitude 10.00 Vpp

DC Offset 0.00 V

Duty Cycle 50 %

Modulation Type None

Sweep Settings

Start Frequency 100 Hz

Stop Frequency 1k Hz

Step 100 Hz

Step Interval 1000 ms

Instrument Control

Device Dev1 (NI myDAQ)

Signal Route AO 0

Digital Multimeter - NI ELVISmx

1.90 V DC

Measurement Settings

Mode Specify Range

Range 20V

Null Offset

Banana Jack Connections

Instrument Control

Device Dev1 (NI myDAQ)

Acquisition Mode Run Continuously

Oscilloscope - NI ELVISmx

Sample Rate: 50.00 kS/s

CH0 Meas: RMS: 3.494 V Freq: 60.006 Hz Vp-p: 9.887 V

Figure 17: Photo diode at 1.90V to bias the MOSFET and allows AC signal to pass.

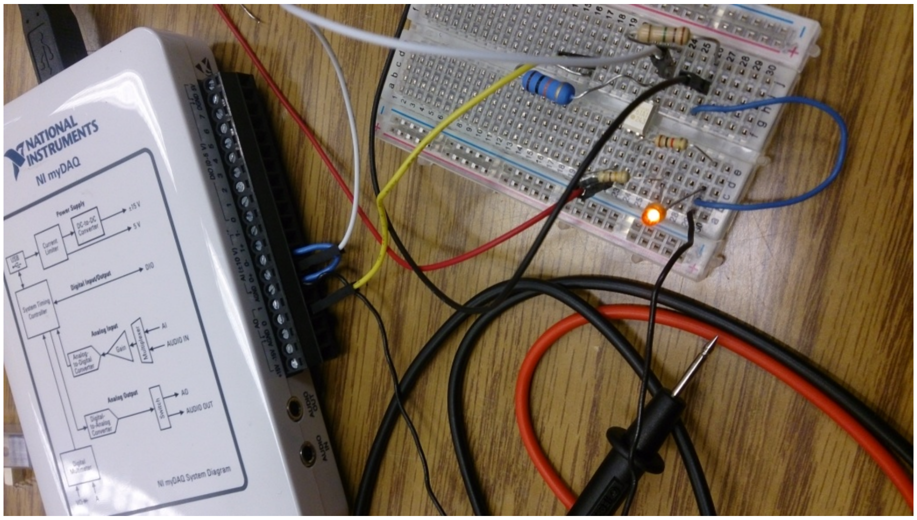


Figure 18: The VDC at 5V to replicate a high from the Arduino.

The relay can now be controlled fully by a digital port from the Arduino allowing the 24VAC from the control board to turn on the fan, compressor and reversing valve. The schematic for adaption looks like **Figures 19** and **20** below.

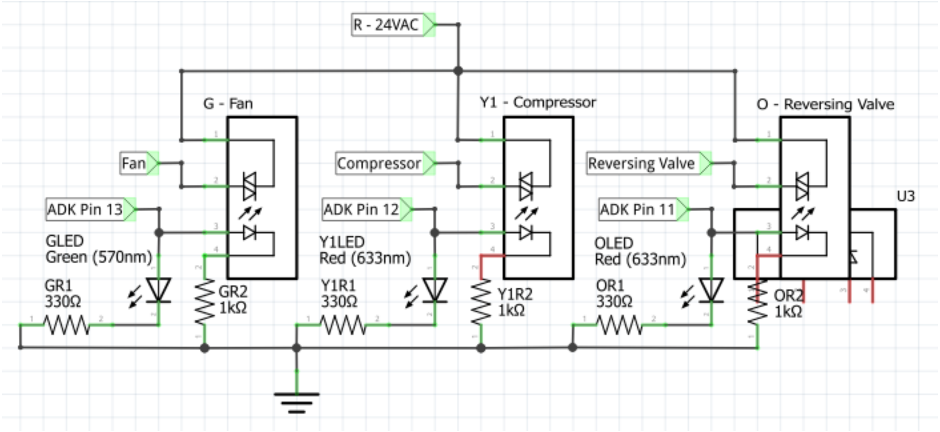


Figure 19: The relay array on schematic.

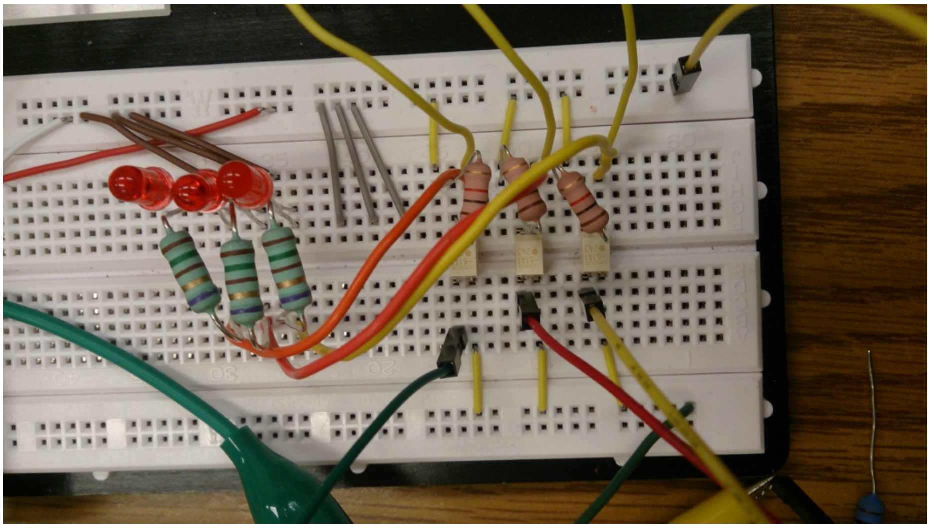


Figure 20: The relay array on breadboard.

The second step was to establish communication between the Arduino and the DXM2 via MAX485. **Figure 21** illustrated the connection between the two boards. Additionally, **Figure 22** shows a successful attempt of communicating with DXM2 and getting a response back on the serial monitor.

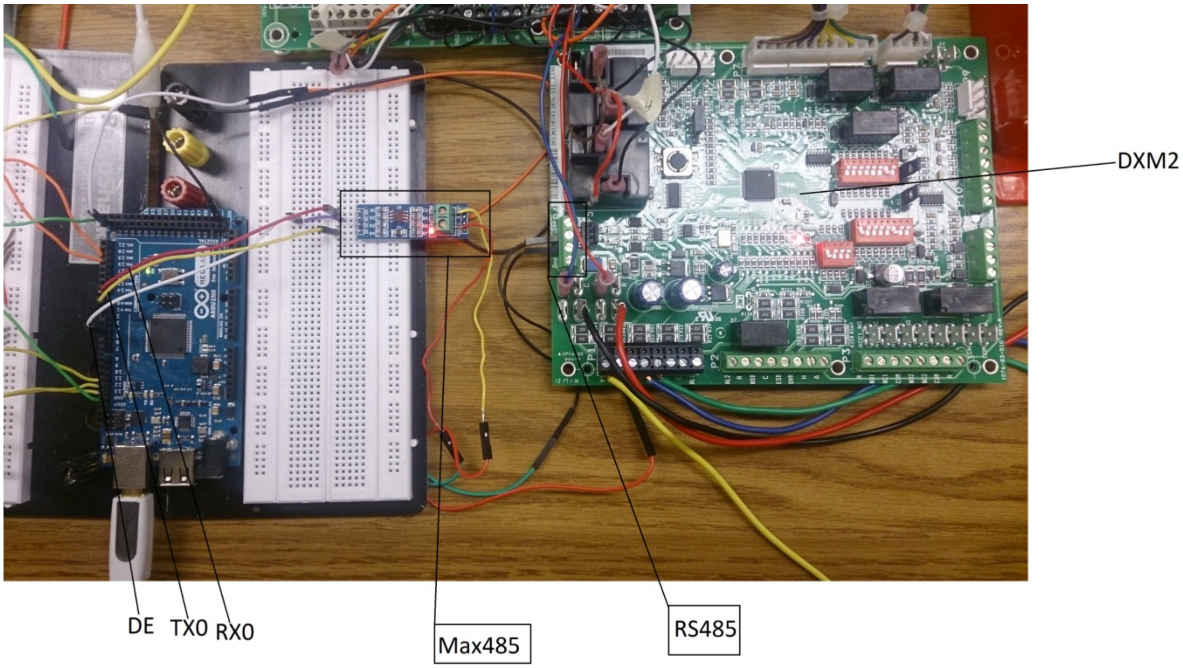
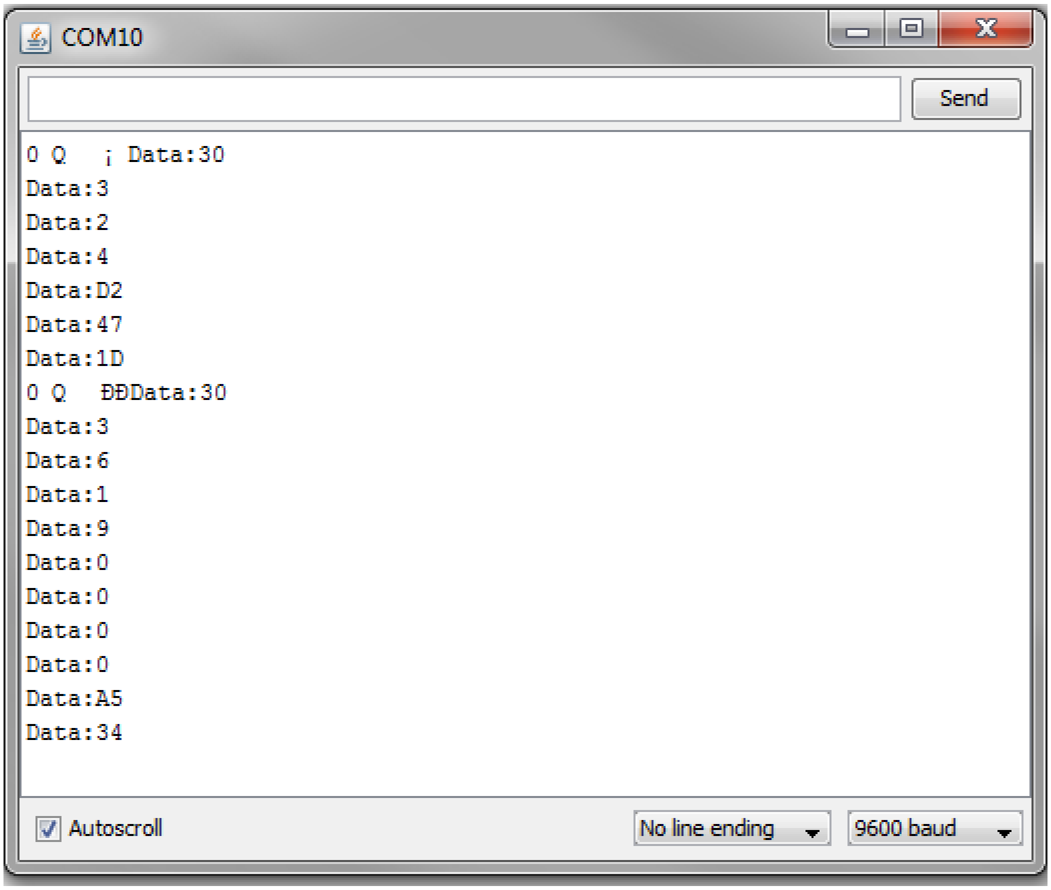


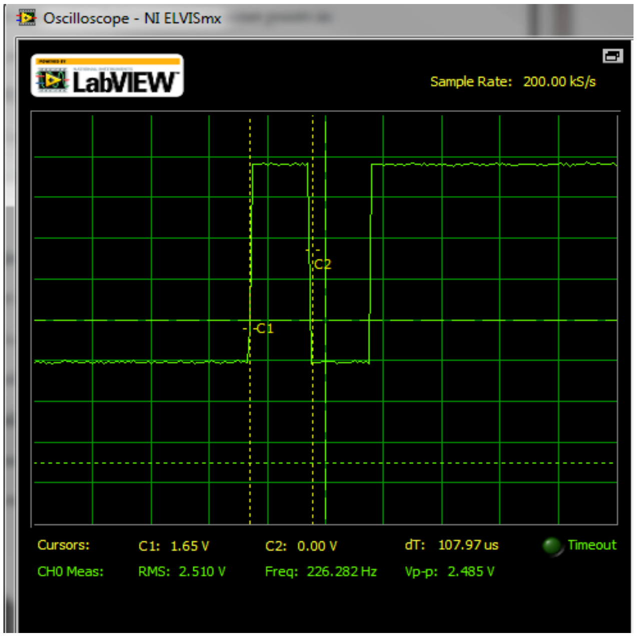
Figure 21: Communication between Arduino and DXM2 via Max485.



```
0 Q   ¡ Data:30
Data:3
Data:2
Data:4
Data:D2
Data:47
Data:1D
0 Q   ĐĐData:30
Data:3
Data:6
Data:1
Data:9
Data:0
Data:0
Data:0
Data:0
Data:A5
Data:34
```

☑ Autoscroll   No line ending   9600 baud

Figure 22: response of the serial number and fault code from the DXM2.



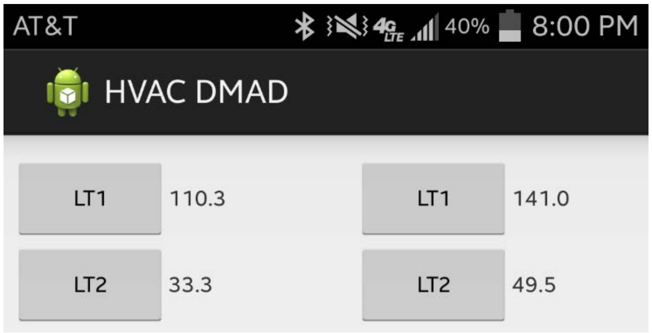
Sample Rate: 200.00 kS/s

Cursors: C1: 1.65 V C2: 0.00 V dT: 107.97 us

CH0 Meas: RMS: 2.510 V Freq: 226.282 Hz Vp-p: 2.485 V

Figure 23: data packet transmitted from the DXM2 using the oscilloscope from MyDAQ.

The following image (**Figure 24**) is a screenshot of part of the application. After the buttons LT1 and LT2 for both Cooling and Heating Mode have been pressed. It is noticeable that the words 'Data' from **Figure 7** have been replaced with temperatures obtained from the DXM2 board.



110.3

141.0

33.3

49.5

Figure 24: screenshot of application after data has been collected.

Data format for all received packets is 1 start bit, 8 data bits, 2 stop bits. Data is transmitted least significant bit first. Data rate is 9.6 Kpbs. The control shall keep its RS485 bus driver disabled (high impedance) when not transmitting, and turn off its driver within 1.2mS of completing transmit of a packet.

The "A+" terminal is non-inverted data and the control provides a weak (12uA nominal) pull-down to ground when the driver is not enabled. The "B–" terminal is inverted data and the control provides a weak (12uA nominal) pull-up to +5VDC. The weak pull-up/pull-down guarantees the bus is idle when no devices are driving the bus.

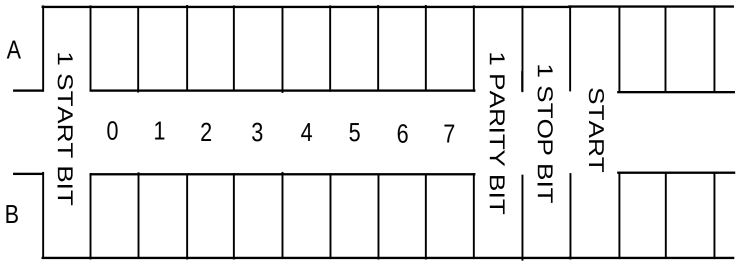


Figure 25: data packet format.

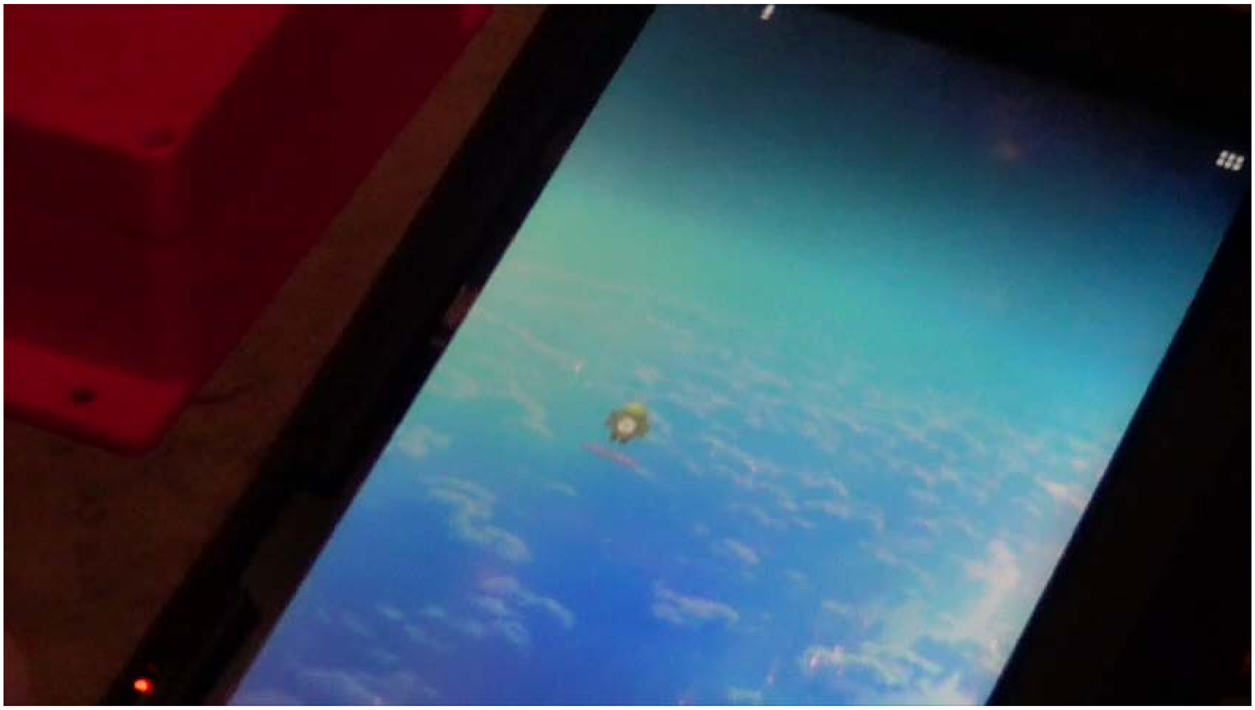
All data is transmitted in packets to allow orderly control over which device is driving the bus. The communication consists of a "Master" device sending command packets, and "slave" devices responding to the packets intended for the slave. Each slave has a unique address, therefore only one device at a time should be transmitting. The packet shall be considered complete if more than 2870uS elapses without receiving a complete byte. Packets may be various lengths as needed for each function code and reply. Packets intended for this control, and sent by this control will not exceed 36 bytes in length (including CRC value).

The slave shall begin reply to queries directed to it 2.5mS after the end of the query packet. If bus activity is detected within this 2.5mS period, the slave cancels the pending reply. The master shall timeout if a response has not begun within 7 ms. The communications bus will be considered idle if no transmissions have occurred for 2.5 seconds. More information about data transmission can be found in Appendix A.

Field Testing

On Tuesday April 8th the group scheduled a field test of the device at the home of a customer who has a ClimateMaster Geothermal Heat Pump installed in her house (Donna). This contact was made through ClimateMaster and the installing contractor Pat from Geothermal Sales and Services.

As the attached video shows, the test was performed flawlessly. First we attached our device in place of the communicating thermostat (the RS485 terminal). Then we connected to the Load Pins (Y1, G, O, R) and to the Power In R and Ground C. After these connections were made we put the unit in test mode (allow us full control over the unit) and subsequently ran the unit in both heating and cooling mode for 10 mins each. While in these modes we were able to measure the temperatures, voltages, and other pertinent information the DXM2 board supplies using the App that was developed and saved the corresponding startup sheet to the Tablet. The whole testing process took approximately 1 hr.



Section IV: Cost Analysis/Estimation

Bill of Materials

Table 1 describes the cost analysis for the whole design. This table shows different components that are included into the design in order to meet the requirements and specifications for the project. Additionally, the table defines the quantities needed for each component and the name for each supplier.

Table 1: Table with information about the different elements of the project

Part Name	Price/Unit	Units		Part Number	Vendor
Arduino Mega ADK	$69.95	1	$69.95	782-A000069	Mouser Electronics
Standoff w/ Hole	$0.39	4	$1.56	SR60-ND	Digi-Key
DFRobot Bluetooth V3	$21.90	1	$21.90	TEL0026	DFRobot
Arduino Prototype Shield	$9.95	1	$9.95	DEV-07914	SparkFun
Enclosure - Flanged (Red)	$7.95	1	$7.95	PRT-11366	SparkFun
Max485 module	$4.50	1	$4.50	EA-100901	YourDruino
Solid State Relays	$2.57	3	$7.71	Z2100-ND	Digi-Key
Beginner Part Kit	$24.95	1	$24.95	KIT-10003	SparkFun
Header, Female 2-pin	$0.29	9	$2.61	S7000-ND	Digi-Key
Toggle Switch	$3.31	1	$3.31	360-3289-ND	Digi-Key
9V Battery Connector	$2.99	1	$2.99	270-324	Radio Shack
9V Battery	$2.39	1	$2.39	A522BP	Radio Shack
Total cost			$159.77		

Cost Analysis

The total cost is $159.77 which is less than the $400 budget allocated by the Engineering Department of IPFW.

Conclusions

The designed system was successfully tested and evaluated on the job site. After initially evaluating the conceptual designs for each area presented previously, it was determined that the service technician would use the Arduino ADK with Bluetooth, Android Smart Phone Device using external memory to back up the files.

This design meets in its entirety the requirements set by ClimateMaster and IPFW which include running the units major components (blower fan, compressor, actuator and reversing valve), collecting and recording the serial number of the DXM2 board that is being tested as well as several temperatures and voltages from the same DXM2 board. The created device is 100% compatible the provided DXM2 board and could also be used in other ClimateMaster boards such as the ECM board but for controlling purposes only since the last mentioned board does not have the RS485 communication ports or the sensors that the DXM2 board has.

Along with the requirements there were also limitation and constraints that were met. The final design was able to work within 0-20 ft. from the unit as this is the standard range the technician stands while operating the unit. In the future the team will be able to know if the sdesign surpasses the test of time and works after at least 10 years which is expected taking into consideration normal wear and tear. The device was able to work with the different voltage ranges on each unit and was safe to use by the technician. The total time spent performing each startup was shorter than the current time a technician spends in the startup process using the analog method.

Lastly, the final cost was determined to be $159.77 which falls within the $400 budget provided by IPFW. Based on the evaluation of the design requirements, limitations, and constraints; it was determined that this design successfully accommodates the desired solution.

References

- Arduino Mega ADK – Last accessed on 5/1/14

  http://arduino.cc/en/Main/ArduinoBoardADK

- MAX-485 datasheet – Last accessed on 5/1/14

  http://yourduino.com/sunshop2/index.php?l=product_detail&p=323

- S112S01 – Last accessed on 5/1/14

  https://www.sparkfun.com/products/10636

- 2N3904 transistor data Sheet – Last accessed on 5/1/14

  http://www.findchips.com/ref/2N3904

- Sample C++ Code – Last accessed on 5/1/14

  http://stackoverflow.com/questions/15735264/android-to-arduino-uno-wi-fi-shield-string-communication

- Data transfer between Android and Arduino via Bluetooth – Last accessed on 5/1/14
  http://english.cxem.net/arduino/arduino5.php

- Arduino Language Reference – Last accessed on 5/1/14
  http://arduino.cc/en/Reference/HomePage

Appendices

Appendix A: DMX2 Control Diagnostics RS 485

1. Introduction

The ClimateMaster DXM2 communicating control uses a Modbus based RS–485 protocol.

2. Physical Communications Interface

All compatible ClimateMaster communicating devices will have appropriate hardware to be connected to a ClimateMaster Modbus based RS485 network.

2.1. Physical Connections

2.1.1. A+ Connection

The A+ connection will be the positive connection for the RS485 serial communications network.

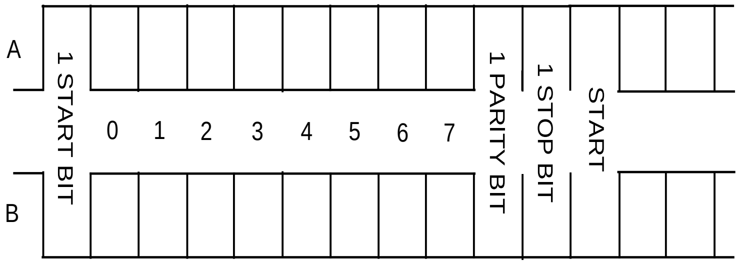
2.1.2. B- Connection

The B– connection will be the negative connection for the RS485 serial communications network.

2.2. Data Structure

Data format is 1 start bit, 8 data bits, 2 stop bits. Data is transmitted least significant bit first. Data rate is 9.6 Kpbs. The control shall keep its RS485 bus driver disabled (high impedance) when not transmitting, and turn off its driver within 1.2mS of completing transmit of a packet.

The "A+" terminal is non-inverted data and the control provides a weak (12uA nominal) pull-down to ground when the driver is not enabled. The "B–" terminal is inverted data and the control provides a weak (12uA nominal) pull-up to +5VDC. The weak pull-up/pull-down guarantees the bus is idle when no devices are driving the bus.



All data is transmitted in packets to allow orderly control over which device is driving the bus. The communication consists of a “Master” device sending command packets, and “slave” devices responding to the packets intended for the slave. Each slave has a unique address, therefore only one device at a time should be transmitting. The packet shall be considered complete if more than 2870uS elapses without receiving a complete byte. Packets may be various lengths as needed for each function code and reply. Packets intended for this control, and sent by this control will not exceed 36 bytes in length (including CRC value).

The slave shall begin reply to queries directed to it 2.5mS after the end of the query packet. If bus activity is detected within this 2.5mS period, the slave cancels the pending reply. The master shall timeout if a response has not begun within 7 ms. The communications bus will be considered idle if no transmissions have occurred for 2.5 seconds.

3. DXM2 Diagnostic Data Packets

The following sections show the required data packets (all values in hexadecimal) to be sent to the DXM2 with dipswitch SW3-1 in the off position, to retrieve the specified data points.

3.1. Serial Number

To read the last four digits of the unit serial number stored in a DXM2 during manufacturing, the following data packet should be sent to the DXM2:

30 03 51 1F 00 01 A1 11

The response packet should be similar to the following, with the highlighted hexadecimal values containing the currently stored 16 bit value:

30 03 02 12 34 C5 80

In this case the response value of 1234 hex is interpreted as 4660

3.2. Fault Codes

To read the current and last five stored fault codes stored in a DXM2, the following data packet should be sent to the DXM2:

30 03 51 1C 00 03 D0 D0

The response packet should be similar to the following, with the highlighted hexadecimal values containing the current and stored fault code values:

30 03 06 01 02 03 04 05 06 4B F3

In this case the response value of 01 would be the current fault code, 02 would be the first stored fault code value, 03 would be the second stored fault code value, 04 would be the third stored fault code value, 05 would be the fourth stored fault code value, and 06 would be the fifth stored fault code value.

3.3. LT1 Temperature

To read the LT1 temperature from a DXM2 the following data packet should be sent to the DXM2:

30 03 51 20 00 01 91 1D

The response packet should be similar to the following, with the highlighted hexadecimal values containing the current LT1 temperature value:

30 03 02 03 06 45 72

Temperature values are in 1/10 degrees F, so the hexadecimal value above of 0x0306 would be translated to a decimal value of 774, equivalent to a temperature of 77.4 degrees.

3.4. LT2 Temperature

To read the LT2 temperature from a DXM2 the following data packet should be sent to the DXM2:

30 03 51 21 00 01 C0 DD

The response packet should be similar to the following, with the highlighted hexadecimal values containing the current LT2 temperature value:

30 03 02 03 06 45 72

Temperature values are in 1/10 degrees F, so the hexadecimal value above of 0x0306 would be translated to a decimal value of 774, equivalent to a temperature of 77.4 degrees.

3.5. Entering Water Temperature

To read the entering water temperature from a DXM2 the following data packet should be sent to the DXM2:

30 03 51 23 00 01 61 1D

The response packet should be similar to the following, with the highlighted hexadecimal values containing the current entering water temperature value:

30 03 02 02 06 45 72

Temperature values are in 1/10 degrees F, so the hexadecimal value above of 0x0206 would be translated to a decimal value of 518, equivalent to a temperature of 51.8 degrees.

3.6. Leaving Water Temperature

To read the leaving water temperature from a DXM2 the following data packet should be sent to the DXM2:

30 03 51 24 00 01 D0 DC

The response packet should be similar to the following, with the highlighted hexadecimal values containing the current leaving water temperature value:

30 03 02 01 E1 45 72

Temperature values are in 1/10 degrees F, so the hexadecimal value above of 0x01E1 would be translated to a decimal value of 481, equivalent to a temperature of 48.1 degrees.

3.7. Leaving Air Temperature

To read the leaving air temperature from a DXM2 the following data packet should be sent to the DXM2:

30 03 51 25 00 01 81 1C

The response packet should be similar to the following, with the highlighted hexadecimal values containing the current leaving air temperature value:

30 03 02 03 16 45 72

Temperature values are in 1/10 degrees F, so the hexadecimal value above of 0x0316 would be translated to a decimal value of 790, equivalent to a temperature of 79.0 degrees.

3.8. Compressor Discharge Temperature

To read the compressor discharge temperature from a DXM2 the following data packet should be sent to the DXM2:

30 03 51 27 00 01 20 DC

The response packet should be similar to the following, with the highlighted hexadecimal values containing the current compressor discharge temperature value:

30 03 02 05 2A 45 72

Temperature values are in 1/10 degrees F, so the hexadecimal value above of 0x052A would be translated to a decimal value of 1322, equivalent to a temperature of 132.2 degrees.

3.9. Entering Hot Water Temperature

To read the entering hot water temperature from a DXM2 the following data packet should be sent to the DXM2:

30 03 51 26 00 01 71 1C

The response packet should be similar to the following, with the highlighted hexadecimal values containing the current entering hot water temperature value:

30 03 02 04 83 45 72

Temperature values are in 1/10 degrees F, so the hexadecimal value above of 0x0483 would be translated to a decimal value of 1155, equivalent to a temperature of 115.5 degrees.

3.10. Target Airflow

To read the target airflow from a DXM2 the following data packet should be sent to the DXM2:

30 03 51 14 00 01 D0 D3

The response packet should be similar to the following, with the highlighted hexadecimal values containing the current target airflow value:

30 03 02 02 26 45 72

Airflow values are in CFM, so the hexadecimal value above of 0x0226 would be translated to a decimal value of 550, equivalent to a target airflow of 550 CFM.

3.11. Blower Speed

To read the blower speed from a DXM2 the following data packet should be sent to the DXM2:

30 03 51 28 00 01 10 DF

The response packet should be similar to the following, with the highlighted hexadecimal values containing the current blower speed value:

30 03 02 01 6F 45 72

Blower speed values are in RPM, so the hexadecimal value above of 0x016F would be translated to a decimal value of 367, equivalent to a blower speed of 367 RPM.

3.12. Pump Speed

To read the target pump speed from a DXM2 the following data packet should be sent to the DXM2:

```
30 03 51 15 00 01 81 13
```

The response packet should be similar to the following, with the highlighted hexadecimal value containing the current target pump speed value:

```
30 03 02 00 28 45 72
```

Pump speed values are in percent, so the hexadecimal value above of 0x28 would be translated to a decimal value of 40, equivalent to a target pump speed of 40%.

3.13. Control Voltage

To read the control voltage from a DXM2 the following data packet should be sent to the DXM2:

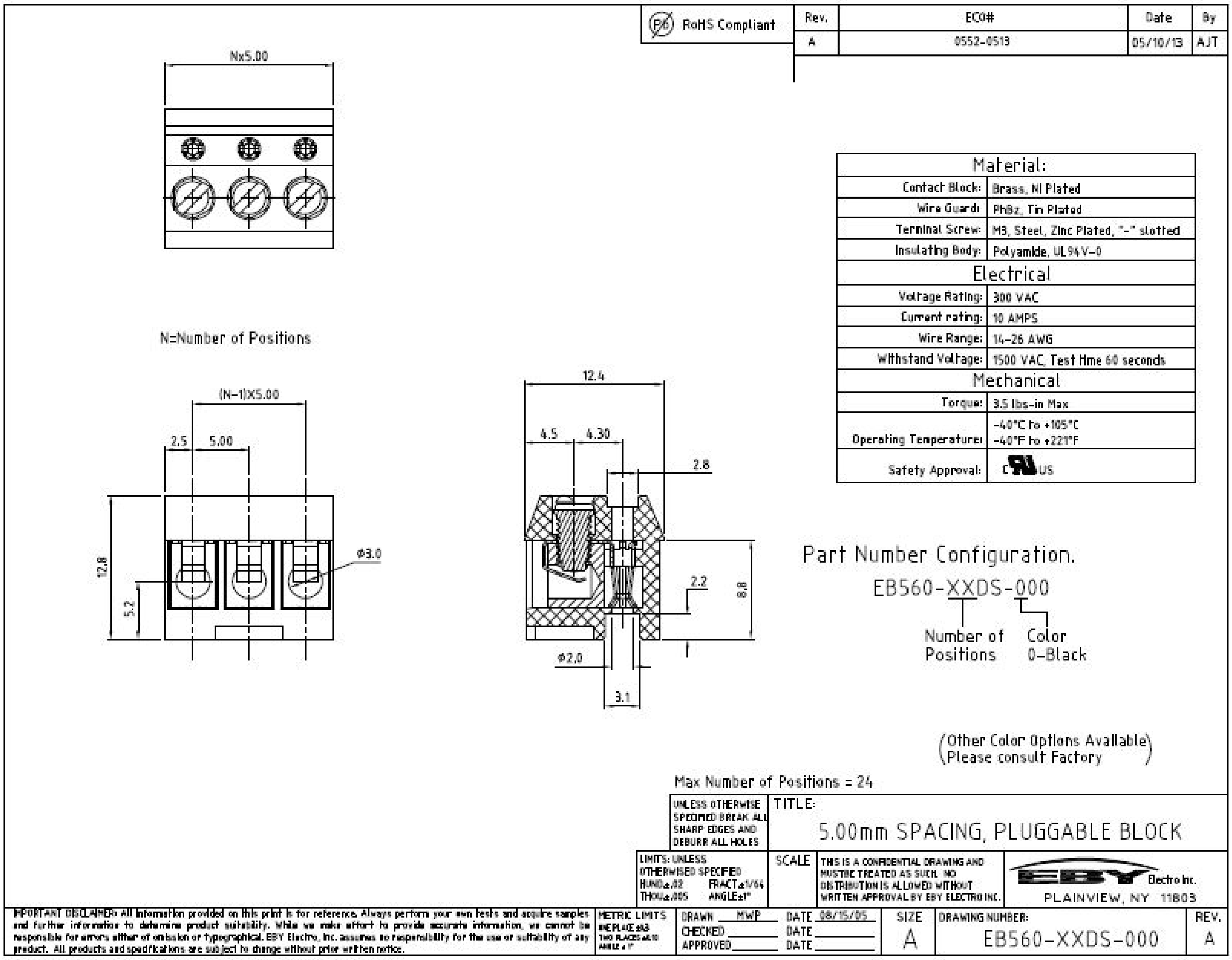
```
30 03 51 2A 00 01 B1 1F
```

The response packet should be similar to the following, with the highlighted hexadecimal values containing the current control voltage value:

```
30 03 02 00 EC C4 0D
```

Temperature values are in 1/10 volts VAC, so the hexadecimal value above of 0x00EC would be translated to a decimal value of 236, equivalent to a voltage of 23.6

Appendix B: DMX2 Data Connector RS485 (schematic)



RoHS Compliant

Rev.	ECO#	Date	By
A	0552-0513	05/10/13	AJT

Material:	
Contact Block:	Brass, NI Plated
Wire Guard:	PhBz, Tin Plated
Terminal Screw:	M3, Steel, Zinc Plated, "-" slotted
Insulating Body:	Polyamide, UL94V-0
Electrical	
Voltage Rating:	300 VAC
Current rating:	10 AMPS
Wire Range:	14-26 AWG
Withstand Voltage:	1500 VAC, Test time 60 seconds
Mechanical	
Torque:	3.5 lbs-in Max
Operating Temperature:	-40°C to +105°C -40°F to +221°F
Safety Approval:	c UL us

(Other Color Options Available
Please consult Factory)

Max Number of Positions = 24

UNLESS OTHERWISE SPECIFIED BREAK ALL SHARP EDGES AND DEBURR ALL HOLES

TITLE: 5.00mm SPACING, PLUGGABLE BLOCK

LIMITS: UNLESS OTHERWISED SPECIFIED
HUND±.02 FRACT±1/64
THOU±.005 ANGLE±1°

SCALE

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METRIC LIMITS
ONE PLACE ±0.3
TWO PLACES ±0.10
ANGLE ± 1°

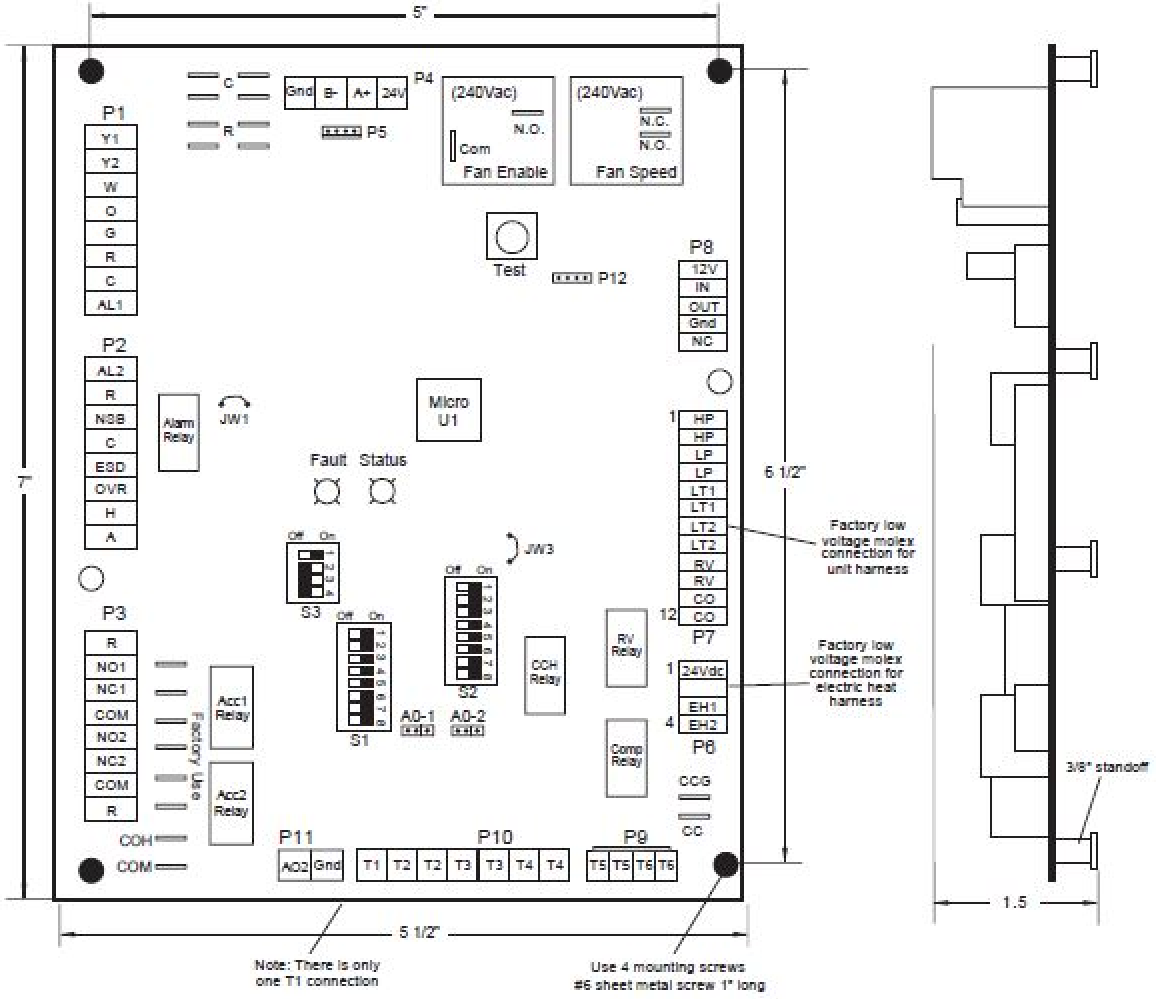
DRAWN MWP DATE 08/15/05
CHECKED ______ DATE ______
APPROVED ______ DATE ______

SIZE A

DRAWING NUMBER: EB560-XXDS-000

REV. A

Appendix C: DXM2 Physical Dimension & Layout



Note: There is only one T1 connection

Use 4 mounting screws #6 sheet metal screw 1" long

Appendix D: Program List

Android Code

HVACDMAD.Java-Main Activity

```
package com.example.hvacdmad;

import android.net.Uri;
import android.os.Bundle;
import android.app.Activity;
import android.view.Menu;

import java.io.File;
import java.io.FileOutputStream;
import java.io.IOException;
import java.io.InputStream;
import java.io.OutputStream;
import java.lang.reflect.Method;
import java.text.DateFormat;
import java.text.SimpleDateFormat;
import java.util.Date;
import java.util.UUID;

//import com.itextpdf.text.pdf.AcroFields;
//import com.itextpdf.text.pdf.PdfReader;
//import com.itextpdf.text.pdf.PdfStamper;

import com.example.hvacdmad.R;
import com.itextpdf.text.pdf.AcroFields;
import com.itextpdf.text.pdf.PdfReader;
import com.itextpdf.text.pdf.PdfStamper;

import android.app.Activity;
import android.bluetooth.BluetoothAdapter;
import android.bluetooth.BluetoothDevice;
import android.bluetooth.BluetoothSocket;
import android.content.ActivityNotFoundException;
import android.content.Intent;
import android.os.Build;
import android.os.Bundle;
import android.os.Environment;
import android.os.Handler;
import android.util.Log;
import android.view.View;
import android.view.View.OnClickListener;
import android.widget.Button;
import android.widget.CompoundButton;
import android.widget.CompoundButton.OnCheckedChangeListener;
import android.widget.TextView;
import android.widget.RadioButton;
import android.widget.ToggleButton;
import android.widget.EditText;
import android.widget.Switch;
import android.widget.Toast;

public class MainActivity extends Activity {
  private static final String TAG = "bluetooth1";

        private static String OUT_FILE = Environment.getExternalStorageDirectory()
                    + "/";

        String Outputfile= "";


  Button Serial, Fault, LT1, LT2, ENTWATER, LEAVWATER, LEAVAIR, COMPDIST, ENTHOTW, TARGETA;
  Button BLOWERS, PUMPS, CONTROLVOLT, GenPDF, ViewPDF;
  Button lt1, lt2, entwater, leavwater, leavair, compdist, enthotw, targeta, blowers;
  Button pumps, controlvolt;
  ToggleButton toggleButton1, toggleButton2;
  Switch switch1;
  TextView DataSerial, DataFault, DataLT1, DataLT2, DataENTWATER, DataLEAVWATER;
  TextView DataLEAVAIR, DataCOMPDIST, DataENTHOTW, DataTARGETA, DataBLOWERS, DataPUMPS;
  TextView DataCONTROLVOLT, Datalt1, Datalt2, Dataentwater, Dataleavwater, Dataleavair;
  TextView Datacompdist, Dataenthotw, Datatargeta, Datablowers, Datapumps, Datacontrolvolt;
  EditText ReturnAirCM, ReturnAirHM, WaterFlowCM, WaterFlowHM;
  EditText CompAmpsCM, CompAmpsHM, CompVoltsCM, CompVoltsHM, MotorAmpsCM,
MotorAmpsHM;
  EditText WaterTDiffCM, WaterTDiffHM, AirTDiffCM, AirTDiffHM;
  EditText Address, Job, Model, UnitLocation, OrderNumber, Antifreeze, Type;
  RadioButton FahrenheitRadio, PSIGradio;
  Handler h;

  final int RECIEVE_MESSAGE = 1;        // Status  for Handler
  private BluetoothAdapter btAdapter = null;
  private BluetoothSocket btSocket = null;
  private OutputStream outStream = null;
  private StringBuilder sb = new StringBuilder();
  private ConnectedThread mConnectedThread;
```

```
// SPP UUID service
private static final UUID MY_UUID = UUID.fromString("00001101-0000-1000-8000-00805F9B34FB");

// MAC-address of Bluetooth module (you must edit this line)
private static String address = "20:13:08:28:05:96";

String sent;

/** Called when the activity is first created. */
@Override
public void onCreate(Bundle savedInstanceState) {
  super.onCreate(savedInstanceState);

  setContentView(R.layout.activity_main2);

  Serial = (Button) findViewById(R.id.Serial);
  Fault = (Button) findViewById(R.id.Fault);
  LT1 = (Button) findViewById(R.id.LT1);
  LT2 = (Button) findViewById(R.id.LT2);
  ENTWATER = (Button) findViewById(R.id.ENTWATER);
  LEAVWATER = (Button) findViewById(R.id.LEAVWATER);
  LEAVAIR = (Button) findViewById(R.id.LEAVAIR);
  COMPDIST = (Button) findViewById(R.id.COMPDIST);
  ENTHOTW = (Button) findViewById(R.id.ENTHOTW);
  TARGETA = (Button) findViewById(R.id.TARGETA);
  BLOWERS = (Button) findViewById(R.id.BLOWERS);
  PUMPS = (Button) findViewById(R.id.PUMPS);
  CONTROLVOLT = (Button) findViewById(R.id.CONTROLVOLT);
  lt1 = (Button) findViewById(R.id.lt1);
  lt2 = (Button) findViewById(R.id.lt2);
  entwater = (Button) findViewById(R.id.entwater);
  leavwater = (Button) findViewById(R.id.leavwater);
  leavair = (Button) findViewById(R.id.leavair);
  compdist = (Button) findViewById(R.id.compdist);
  enthotw = (Button) findViewById(R.id.enthotw);
  targeta = (Button) findViewById(R.id.targeta);
  blowers = (Button) findViewById(R.id.blowers);
  pumps = (Button) findViewById(R.id.pumps);
  controlvolt  = (Button) findViewById(R.id.controlvolt);
        toggleButton1 = (ToggleButton) findViewById(R.id.toggleButton1);
        toggleButton2 = (ToggleButton) findViewById(R.id.toggleButton2);
        switch1 = (Switch) findViewById(R.id.switch1);
        DataSerial = (TextView) findViewById(R.id.DataSerial);
```

```
DataFault = (TextView) findViewById(R.id.DataFault);
DataLT1 = (TextView) findViewById(R.id.DataLT1);
DataLT2 = (TextView) findViewById(R.id.DataLT2);
DataENTWATER = (TextView) findViewById(R.id.DataENTWATER);
DataLEAVWATER = (TextView) findViewById(R.id.DataLEAVWATER);
DataLEAVAIR = (TextView) findViewById(R.id.DataLEAVAIR);
DataCOMPDIST = (TextView) findViewById(R.id.DataCOMPDIST);
DataENTHOTW = (TextView) findViewById(R.id.DataENTHOTW);
DataTARGETA = (TextView) findViewById(R.id.DataTARGETA);
DataBLOWERS = (TextView) findViewById(R.id.DataBLOWERS);
DataPUMPS = (TextView) findViewById(R.id.DataPUMPS);
DataCONTROLVOLT = (TextView) findViewById(R.id.DataCONTROLVOLT);
Datalt1 = (TextView) findViewById(R.id.Datalt1);
Datalt2 = (TextView) findViewById(R.id.Datalt2);
Dataentwater = (TextView) findViewById(R.id.Dataentwater);
Dataleavwater = (TextView) findViewById(R.id.Dataleavwater);
Dataleavair = (TextView) findViewById(R.id.Dataleavair);
Datacompdist = (TextView) findViewById(R.id.Datacompdist);
Dataenthotw = (TextView) findViewById(R.id.Dataenthotw);
Datatargeta = (TextView) findViewById(R.id.Datatargeta);
Datablowers = (TextView) findViewById(R.id.Datablowers);
Datapumps = (TextView) findViewById(R.id.Datapumps);
Datacontrolvolt = (TextView) findViewById(R.id.Datacontrolvolt);
FahrenheitRadio = (RadioButton) findViewById(R.id.radio0);
PSIGradio = (RadioButton) findViewById(R.id.radio2);

Address = (EditText) findViewById(R.id.Address);
Job = (EditText) findViewById(R.id.Job);
Model = (EditText) findViewById(R.id.Model);
UnitLocation = (EditText) findViewById(R.id.UnitLocation);
OrderNumber = (EditText) findViewById(R.id.OrderNumber);
Antifreeze = (EditText) findViewById(R.id.Antifreeze);
Type = (EditText) findViewById(R.id.Type);
ReturnAirCM = (EditText) findViewById(R.id.ReturnAirCM);
ReturnAirHM = (EditText) findViewById(R.id.ReturnAirHM);
WaterFlowCM = (EditText) findViewById(R.id.WaterFlowCM);
WaterFlowHM = (EditText) findViewById(R.id.WaterFlowHM);
CompAmpsCM = (EditText) findViewById(R.id.CompAmpsCM);
CompAmpsHM = (EditText) findViewById(R.id.CompAmpsHM);
CompVoltsCM = (EditText) findViewById(R.id.CompVoltsCM);
CompVoltsHM = (EditText) findViewById(R.id.CompVoltsHM);
MotorAmpsCM = (EditText) findViewById(R.id.MotorAmpsCM);
MotorAmpsHM = (EditText) findViewById(R.id.MotorAmpsHM);
WaterTDiffCM = (EditText) findViewById(R.id.WaterTDiffCM);
```

```
     WaterTDiffHM = (EditText) findViewById(R.id.WaterTDiffHM);
     AirTDiffCM = (EditText) findViewById(R.id.AirTDiffCM);
     AirTDiffHM = (EditText) findViewById(R.id.AirTDiffHM);


h = new Handler() {
  public void handleMessage(android.os.Message msg) {
    switch (msg.what) {
    case RECIEVE_MESSAGE:                                   // if receive massage
     byte[] readBuf = (byte[]) msg.obj;
      String strIncom = new String(readBuf, 0, msg.arg1);          // create string from bytes array
      sb.append(strIncom);                                  // append string
      int endOfLineIndex = sb.indexOf("\r\n");                    // determine the end-of-line

      //String s = sent.charAt(0) + " " + sb.toString();
     //Log.d("test2", s);

      switch (sent.charAt(0)){
      case 'S':

        if (endOfLineIndex > 0) {                           // if end-of-line,
             String sbprint = sb.substring(0, endOfLineIndex);          // extract string
          sb.delete(0, sb.length());                        // and clear
          DataSerial.setText(sbprint);          // update TextView
          Serial.setEnabled(true);
        }

        break;

      case 'F':

        if (endOfLineIndex > 0) {                           // if end-of-line,
             String sbprint = sb.substring(0, endOfLineIndex);          // extract string
          sb.delete(0, sb.length());                        // and clear
          DataFault.setText(sbprint);          // update TextView
          Fault.setEnabled(true);
        }

        break;
      case 'L':

        if (endOfLineIndex > 0) {                           // if end-of-line,
             String sbprint = sb.substring(0, endOfLineIndex);          // extract string
          sb.delete(0, sb.length());                        // and clear
    DataLT1.setText(sbprint);          // update TextView
    LT1.setEnabled(true);
  }
  break;
case '1':

  if (endOfLineIndex > 0) {                                   // if end-of-line,
      String sbprint = sb.substring(0, endOfLineIndex);             // extract string
    sb.delete(0, sb.length());                                 // and clear
    Datalt1.setText(sbprint);          // update TextView
    lt1.setEnabled(true);
  }
  break;
case 'l':

  if (endOfLineIndex > 0) {                                   // if end-of-line,
      String sbprint = sb.substring(0, endOfLineIndex);             // extract string
    sb.delete(0, sb.length());                                 // and clear
    DataLT2.setText(sbprint);          // update TextView
    LT2.setEnabled(true);
  }
  break;
case '2':

  if (endOfLineIndex > 0) {                                   // if end-of-line,
      String sbprint = sb.substring(0, endOfLineIndex);             // extract string
    sb.delete(0, sb.length());                                 // and clear
    Datalt2.setText(sbprint);          // update TextView
    lt2.setEnabled(true);
  }
  break;
case 'W':

  if (endOfLineIndex > 0) {                                   // if end-of-line,
      String sbprint = sb.substring(0, endOfLineIndex);             // extract string
    sb.delete(0, sb.length());                                 // and clear
    DataENTWATER.setText(sbprint);          // update TextView
    ENTWATER.setEnabled(true);
  }
  break;
case 'w':

  if (endOfLineIndex > 0) {                                   // if end-of-line,
      String sbprint = sb.substring(0, endOfLineIndex);             // extract string
      sb.delete(0, sb.length());                         // and clear
      Dataentwater.setText(sbprint);          // update TextView
      entwater.setEnabled(true);
   }
   break;
case 'R':

   if (endOfLineIndex > 0) {                              // if end-of-line,
          String sbprint = sb.substring(0, endOfLineIndex);          // extract string
      sb.delete(0, sb.length());                         // and clear
      DataLEAVWATER.setText(sbprint);          // update TextView
      LEAVWATER.setEnabled(true);
   }
   break;
case 'r':

   if (endOfLineIndex > 0) {                              // if end-of-line,
          String sbprint = sb.substring(0, endOfLineIndex);          // extract string
      sb.delete(0, sb.length());                         // and clear
      Dataleavwater.setText(sbprint);          // update TextView
      leavwater.setEnabled(true);
   }
   break;
case 'A':

   if (endOfLineIndex > 0) {                              // if end-of-line,
          String sbprint = sb.substring(0, endOfLineIndex);          // extract string
      sb.delete(0, sb.length());                         // and clear
      DataLEAVAIR.setText(sbprint);          // update TextView
      LEAVAIR.setEnabled(true);
   }
   break;
case 'a':

   if (endOfLineIndex > 0) {                              // if end-of-line,
          String sbprint = sb.substring(0, endOfLineIndex);          // extract string
      sb.delete(0, sb.length());                         // and clear
      Dataleavair.setText(sbprint);          // update TextView
      leavair.setEnabled(true);
   }
   break;
case 'D':

   if (endOfLineIndex > 0) {                              // if end-of-line,
          String sbprint = sb.substring(0, endOfLineIndex);             // extract string
      sb.delete(0, sb.length());                                // and clear
      DataCOMPDIST.setText(sbprint);           // update TextView
      COMPDIST.setEnabled(true);
   }
   break;
case 'd':

   if (endOfLineIndex > 0) {                                  // if end-of-line,
          String sbprint = sb.substring(0, endOfLineIndex);             // extract string
      sb.delete(0, sb.length());                                // and clear
      Datacompdist.setText(sbprint);           // update TextView
      compdist.setEnabled(true);
   }
   break;
case 'E':

   if (endOfLineIndex > 0) {                                  // if end-of-line,
          String sbprint = sb.substring(0, endOfLineIndex);             // extract string
      sb.delete(0, sb.length());                                // and clear
      DataENTHOTW.setText(sbprint);           // update TextView
      ENTHOTW.setEnabled(true);
   }
   break;
case 'e':

   if (endOfLineIndex > 0) {                                  // if end-of-line,
          String sbprint = sb.substring(0, endOfLineIndex);             // extract string
      sb.delete(0, sb.length());                                // and clear
      Dataenthotw.setText(sbprint);           // update TextView
      enthotw.setEnabled(true);
   }
   break;
case 'G':

   if (endOfLineIndex > 0) {                                  // if end-of-line,
          String sbprint = sb.substring(0, endOfLineIndex);             // extract string
      sb.delete(0, sb.length());                                // and clear
      DataTARGETA.setText(sbprint);           // update TextView
      TARGETA.setEnabled(true);
   }
   break;
case 'g':
  if (endOfLineIndex > 0) {                    // if end-of-line,
      String sbprint = sb.substring(0, endOfLineIndex);      // extract string
    sb.delete(0, sb.length());                 // and clear
    Datatargeta.setText(sbprint);        // update TextView
    targeta.setEnabled(true);
  }
  break;
case 'B':

  if (endOfLineIndex > 0) {                    // if end-of-line,
      String sbprint = sb.substring(0, endOfLineIndex);      // extract string
    sb.delete(0, sb.length());                 // and clear
    DataBLOWERS.setText(sbprint);        // update TextView
    BLOWERS.setEnabled(true);
  }
  break;
case 'b':

  if (endOfLineIndex > 0) {                    // if end-of-line,
      String sbprint = sb.substring(0, endOfLineIndex);      // extract string
    sb.delete(0, sb.length());                 // and clear
    Datablowers.setText(sbprint);        // update TextView
    blowers.setEnabled(true);
  }
  break;
case 'P':

  if (endOfLineIndex > 0) {                    // if end-of-line,
      String sbprint = sb.substring(0, endOfLineIndex);      // extract string
    sb.delete(0, sb.length());                 // and clear
    DataPUMPS.setText(sbprint);        // update TextView
    PUMPS.setEnabled(true);
  }
  break;
case 'p':

  if (endOfLineIndex > 0) {                    // if end-of-line,
      String sbprint = sb.substring(0, endOfLineIndex);      // extract string
    sb.delete(0, sb.length());                 // and clear
    Datapumps.setText(sbprint);        // update TextView
    pumps.setEnabled(true);
  }
  break;
case 'V':
        if (endOfLineIndex > 0) {                                   // if end-of-line,
             String sbprint = sb.substring(0, endOfLineIndex);             // extract string
          sb.delete(0, sb.length());                                // and clear
          DataCONTROLVOLT.setText(sbprint);           // update TextView
          CONTROLVOLT.setEnabled(true);
        }
        break;
      case 'v':

        if (endOfLineIndex > 0) {                                   // if end-of-line,
             String sbprint = sb.substring(0, endOfLineIndex);             // extract string
          sb.delete(0, sb.length());                                // and clear
          Datacontrolvolt.setText(sbprint);           // update TextView
          controlvolt.setEnabled(true);
        }
        break;

      }

      //Log.d(TAG, "...String:"+ sb.toString() +  "Byte:" + msg.arg1 + "...");
      break;
    }
  };
};


btAdapter = BluetoothAdapter.getDefaultAdapter();
checkBTState();

switch1.setOnCheckedChangeListener(new CompoundButton.OnCheckedChangeListener() {
  public void onCheckedChanged(CompoundButton buttonView, boolean isChecked) {
    if (isChecked){ // Do Something
       sendData("T");
    } else {
      if (buttonView != toggleButton1) {
        toggleButton1.setChecked(false);
        sendData("c");
      }
      if (buttonView != toggleButton2) {
        toggleButton2.setChecked(false);
        sendData("h");
       }
       sendData("t");
    }
  }
});

toggleButton1.setOnCheckedChangeListener(new CompoundButton.OnCheckedChangeListener() {
  public void onCheckedChanged(CompoundButton buttonView, boolean isChecked) {
    if (isChecked && buttonView != toggleButton2) {
     sendData("C");  // The toggle is enabled
     toggleButton2.setChecked(false);
     toggleButton2.setEnabled(false);
     Toast.makeText(getBaseContext(), "Cooling Mode ON!", Toast.LENGTH_SHORT).show();
      }
    else {
      sendData("c");  // The toggle is disabled
    toggleButton2.setEnabled(true);
    Toast.makeText(getBaseContext(), "Cooling Mode OFF!", Toast.LENGTH_SHORT).show();

    }
  }
});

toggleButton2.setOnCheckedChangeListener(new CompoundButton.OnCheckedChangeListener() {
  public void onCheckedChanged(CompoundButton buttonView, boolean isChecked) {
    if (isChecked && buttonView != toggleButton1) {
     sendData("H");  // The toggle is enabled
     toggleButton1.setChecked(false);
     toggleButton1.setEnabled(false);
     Toast.makeText(getBaseContext(), "Heating Mode ON!", Toast.LENGTH_SHORT).show();
    }
    else {
    sendData("h");  // The toggle is disabled
    toggleButton1.setEnabled(true);
    Toast.makeText(getBaseContext(), "Heating Mode OFF!", Toast.LENGTH_SHORT).show();
    }
  }
});

Serial.setOnClickListener(new OnClickListener() {
 public void onClick(View v) {
  sendData("S");
  Toast.makeText(getBaseContext(), "Receiving Serial Number", Toast.LENGTH_SHORT).show();
 }
});
```

```
  Fault.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
       DataFault.setText("");
     sendData("F");
     Toast.makeText(getBaseContext(), "Receiving Fault Codes", Toast.LENGTH_SHORT).show();
    }
   });

  LT1.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("L");
     Toast.makeText(getBaseContext(), "Receiving LT1 Data", Toast.LENGTH_SHORT).show();
    }
   });

  lt1.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("1");
     Toast.makeText(getBaseContext(), "Receiving LT1 Data", Toast.LENGTH_SHORT).show();
    }
   });

  LT2.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("l");
     Toast.makeText(getBaseContext(), "Receiving LT2 Data", Toast.LENGTH_SHORT).show();
    }
   });

  lt2.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("2");
     Toast.makeText(getBaseContext(), "Receiving LT2 Data", Toast.LENGTH_SHORT).show();
    }
   });

  ENTWATER.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("W");
     Toast.makeText(getBaseContext(), "Receiving Entering Water Temperature",
Toast.LENGTH_SHORT).show();
    }
   });
  entwater.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("w");
     Toast.makeText(getBaseContext(), "Receiving Entering Water Temperature",
Toast.LENGTH_SHORT).show();
    }
   });

  LEAVWATER.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("R");
     Toast.makeText(getBaseContext(), "Receiving Leaving Water Temperature",
Toast.LENGTH_SHORT).show();
    }
   });

  leavwater.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("r");
     Toast.makeText(getBaseContext(), "Receiving Leaving Water Temperature",
Toast.LENGTH_SHORT).show();
    }
   });

  LEAVAIR.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("A");
     Toast.makeText(getBaseContext(), "Receiving Leaving Air Temperature",
Toast.LENGTH_SHORT).show();
    }
   });

  leavair.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("a");
     Toast.makeText(getBaseContext(), "Receiving Leaving Air Temperature",
Toast.LENGTH_SHORT).show();
    }
   });

  COMPDIST.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("D");
     Toast.makeText(getBaseContext(), "Receiving Compressor Discharge Temperature",
Toast.LENGTH_SHORT).show();
    }
   });

  compdist.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("d");
     Toast.makeText(getBaseContext(), "Receiving Compressor Discharge Temperature",
Toast.LENGTH_SHORT).show();
    }
   });

  ENTHOTW.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("E");
     Toast.makeText(getBaseContext(), "Receiving Entering Hot Water Temperature",
Toast.LENGTH_SHORT).show();
    }
   });

  enthotw.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("e");
     Toast.makeText(getBaseContext(), "Receiving Entering Hot Water Temperature",
Toast.LENGTH_SHORT).show();
    }
   });

  TARGETA.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("G");
     Toast.makeText(getBaseContext(), "Receiving Target Airflow", Toast.LENGTH_SHORT).show();
    }
   });

  targeta.setOnClickListener(new OnClickListener() {
    public void onClick(View v) {
     sendData("g");
     Toast.makeText(getBaseContext(), "Receiving Target Airflow", Toast.LENGTH_SHORT).show();
    }
   });

  BLOWERS.setOnClickListener(new OnClickListener() {
   public void onClick(View v) {
    sendData("B");
    Toast.makeText(getBaseContext(), "Receiving Blower Speed", Toast.LENGTH_SHORT).show();
   }
  });

blowers.setOnClickListener(new OnClickListener() {
   public void onClick(View v) {
    sendData("b");
    Toast.makeText(getBaseContext(), "Receiving Blower Speed", Toast.LENGTH_SHORT).show();
   }
  });

PUMPS.setOnClickListener(new OnClickListener() {
   public void onClick(View v) {
    sendData("P");
    Toast.makeText(getBaseContext(), "Receiving Pump Speed", Toast.LENGTH_SHORT).show();
   }
  });

pumps.setOnClickListener(new OnClickListener() {
   public void onClick(View v) {
    sendData("p");
    Toast.makeText(getBaseContext(), "Receiving Pump Speed", Toast.LENGTH_SHORT).show();
   }
  });

CONTROLVOLT.setOnClickListener(new OnClickListener() {
   public void onClick(View v) {
    sendData("V");
    Toast.makeText(getBaseContext(), "Receiving Control Voltage", Toast.LENGTH_SHORT).show();
   }
  });

controlvolt.setOnClickListener(new OnClickListener() {
   public void onClick(View v) {
    sendData("v");
    Toast.makeText(getBaseContext(), "Receiving Control Voltage", Toast.LENGTH_SHORT).show();
   }
  });


      GenPDF = (Button) findViewById(R.id.GenPDF);
      GenPDF.setOnClickListener(new OnClickListener() {
        @Override
        public void onClick(View arg0) {
            /*
             * Generate the PDF
             */
            try {
                // Open the PDF form
                PdfReader reader = new
PdfReader(getResources().openRawResource(R.raw.startupsheetclimatemaster));

                // Get the current date/time
                DateFormat dateFormat = new SimpleDateFormat("MMMM dd, yyyy
HH:mm:ss");
                Date date = new Date();

                // Create a copy of the PDF form
                Outputfile=OUT_FILE + dateFormat.format(date)+".pdf";
                PdfStamper stamper = new PdfStamper(reader, new
FileOutputStream(Outputfile));

                // Get the fields in the form
                AcroFields form = stamper.getAcroFields();

                // Fill in the date field
                form.setField("Date", dateFormat.format(date));

                // Fill in the Job field
                form.setField("Job", Job.getText().toString());

                // Fill in the Address field
                form.setField("Address", Address.getText().toString());

                // Fill in the Model field
                form.setField("Model", Model.getText().toString());

                // Fill in the Location field
                form.setField("Location", UnitLocation.getText().toString());

                // Fill in the Sales field
                form.setField("Sales", OrderNumber.getText().toString());

                // Fill in the Serial field
                form.setField("Serial", DataSerial.getText().toString());
```

```
// Fill in the Fan Motor: Speed Tap (PSC) field
form.setField("Tap", DataBLOWERS.getText().toString());

// Fill in the Entering Fluid Temperature field for Cooling Mode
form.setField("EnteringFCM", DataENTWATER.getText().toString());

// Fill in the Entering Fluid Temperature field for Heating Mode
form.setField("EnteringFHM", Dataentwater.getText().toString());

// Fill in the Leaving Fluid Temperature field for Cooling Mode
form.setField("LeavingFCM", DataLEAVWATER.getText().toString());

// Fill in the Leaving Fluid Temperature field for Heating Mode
form.setField("LeavingFHM", Dataleavwater.getText().toString());

// Fill in the Differential Fluid Temperature field for Cooling Mode
form.setField("FluidTempDiffCM", WaterTDiffCM.getText().toString());

// Fill in the Differential Fluid Temperature field for Heating Mode
form.setField("FluidTempDiffHM", WaterTDiffHM.getText().toString());

// Fill in the Leaving Air Temperature field for Cooling Mode
form.setField("SupplyDBCM", DataLEAVAIR.getText().toString());

// Fill in the Leaving Air Temperature field for Cooling Mode
form.setField("SupplyDBHM", Dataleavair.getText().toString());

// Fill in the Return Air Temperature field for Cooling Mode
form.setField("ReturnDBCM", ReturnAirCM.getText().toString());

// Fill in the Return Air Temperature field for Heating Mode
form.setField("ReturnDBHM", ReturnAirHM.getText().toString());

// Fill in the Differential Air Temperature field for Cooling Mode
form.setField("AirTempDiffCM", AirTDiffCM.getText().toString());

// Fill in the Differential Air Temperature field for Heating Mode
form.setField("AirTempDiffHM", AirTDiffHM.getText().toString());

// Fill in the Water Flow GPM field for Cooling Mode
form.setField("WaterFlowCM", WaterFlowCM.getText().toString());

// Fill in the Water Flow GPM field for Heating Mode
form.setField("WaterFlowHM", WaterFlowHM.getText().toString());
```

```
                    // Fill in the Compressor Amps field for Cooling Mode
                    form.setField("CompAmpsCM", CompAmpsCM.getText().toString());

                    // Fill in the Compressor Amps field for Heating Mode
                    form.setField("CompAmpsHM", CompAmpsHM.getText().toString());

                    // Fill in the Compressor Volts field for Cooling Mode
                    form.setField("CompVoltsCM", CompVoltsCM.getText().toString());

                    // Fill in the Compressor Volts field for Heating Mode
                    form.setField("CompVoltsHM", CompVoltsHM.getText().toString());

                    // Fill in the Compressor Discharge Temperature field for Cooling Mode
                    form.setField("DLineTempCM", DataCOMPDIST.getText().toString());

                    // Fill in the Compressor Discharge Temperature field for Heating Mode
                    form.setField("DLineTempHM", Datacompdist.getText().toString());

                    // Fill in the Motor Amps field for Cooling Mode
                    form.setField("MotorAmpsCM", MotorAmpsCM.getText().toString());

                    // Fill in the Motor Amps field for Heating Mode
                    form.setField("MotorAmpsHM", MotorAmpsHM.getText().toString());

                    // Fill in the Motor Voltage field for Cooling Mode
                    form.setField("MotorVoltsCM",
DataCONTROLVOLT.getText().toString());

                    // Fill in the Motor Voltage field for Cooling Mode
                    form.setField("MotorVoltsHM", Datacontrolvolt.getText().toString());

                    // Fill in the Antifreeze field for Cooling Mode
                    form.setField("Antifreeze", Antifreeze.getText().toString());

                    // Fill in the Type field for Cooling Mode
                    form.setField("Type", Type.getText().toString());

                    // Check the F or F check box
                    if(FahrenheitRadio.isChecked()) {
                         form.setField("F", "Yes");
                    }
                    else {
                         form.setField("C", "Yes");
```

```
                       }

                       // Check the f or c check box
                       if(PSIGradio.isChecked()) {
                              form.setField("PSIG", "Yes");
                       }
                       else {
                              form.setField("kPa", "Yes");
                       }

                       stamper.close();
             reader.close();

                       Toast.makeText(getApplicationContext(), "PDF Created",
                                      Toast.LENGTH_LONG).show();

                       ViewPDF.setEnabled(true);
                } catch (Exception e) {
                       e.printStackTrace();
                       Toast.makeText(getApplicationContext(),
                                      "Error: PDF Not Created", Toast.LENGTH_LONG).show();
                }
        }
 });

 ViewPDF = (Button) findViewById(R.id.ViewPDF);
 ViewPDF.setOnClickListener(new OnClickListener() {
        @Override
        public void onClick(View arg0) {
                /*
                 * View the PDF
                 */
                File file = new File(Outputfile);

if (file.exists()) {
  Uri path = Uri.fromFile(file);
  Intent intent = new Intent(Intent.ACTION_VIEW);
  intent.setDataAndType(path, "application/pdf");
  intent.setFlags(Intent.FLAG_ACTIVITY_CLEAR_TOP);

  try {
    startActivity(intent);
  }
  catch (ActivityNotFoundException e) {
          Toast.makeText(getApplicationContext(),
            "No Application Available to View PDF",
            Toast.LENGTH_SHORT).show();
        }
      }
               }
       });

       ViewPDF.setEnabled(false);


 }

 private BluetoothSocket createBluetoothSocket(BluetoothDevice device) throws IOException {
   if(Build.VERSION.SDK_INT >= 10){
     try {
       final Method  m = device.getClass().getMethod("createInsecureRfcommSocketToServiceRecord",
new Class[] { UUID.class });
       return (BluetoothSocket) m.invoke(device, MY_UUID);
     } catch (Exception e) {
       Log.e(TAG, "Could not create Insecure RFComm Connection",e);
     }
   }
   return  device.createRfcommSocketToServiceRecord(MY_UUID);
 }

 @Override
 public void onResume() {
  super.onResume();

  Log.d(TAG, "...onResume - try connect...");

  // Set up a pointer to the remote node using it's address.
  BluetoothDevice device = btAdapter.getRemoteDevice(address);

  // Two things are needed to make a connection:
  //   A MAC address, which we got above.
  //   A Service ID or UUID.  In this case we are using the
  //     UUID for SPP.

  try {
       btSocket = device.createRfcommSocketToServiceRecord(MY_UUID);
  } catch (IOException e1) {
    Log.d(TAG, "...onResume - fail...");
```

```
        e1.printStackTrace();
        errorExit("Fatal Error", "In onResume() and socket create failed: " + e1.getMessage() + ".");
    }

    // Discovery is resource intensive.  Make sure it isn't going on
    // when you attempt to connect and pass your message.
    btAdapter.cancelDiscovery();

    // Establish the connection.  This will block until it connects.
    Log.d(TAG, "...Connecting...");
    try {
      btSocket.connect();
      Log.d(TAG, "...Connection ok...");
    } catch (IOException e) {
      try {
        btSocket.close();
      } catch (IOException e2) {
        errorExit("Fatal Error", "In onResume() and unable to close socket during connection failure" +
e2.getMessage() + ".");
      }
    }

    // Create a data stream so we can talk to server.
    Log.d(TAG, "...Create Socket...");

    mConnectedThread = new ConnectedThread(btSocket);
    mConnectedThread.start();

    try {
      outStream = btSocket.getOutputStream();
    } catch (IOException e) {
      errorExit("Fatal Error", "In onResume() and output stream creation failed:" + e.getMessage() + ".");
    }
  }

  @Override
  public void onPause() {
    super.onPause();

    Log.d(TAG, "...In onPause()...");

    if (outStream != null) {
      try {
        outStream.flush();
  } catch (IOException e) {
   errorExit("Fatal Error", "In onPause() and failed to flush output stream: " + e.getMessage() + ".");
  }
 }

 try   {
  btSocket.close();
 } catch (IOException e2) {
  errorExit("Fatal Error", "In onPause() and failed to close socket." + e2.getMessage() + ".");
 }
}

private void checkBTState() {
 // Check for Bluetooth support and then check to make sure it is turned on
 // Emulator doesn't support Bluetooth and will return null
 if(btAdapter==null) {
  errorExit("Fatal Error", "Bluetooth not support");
 } else {
  if (btAdapter.isEnabled()) {
   Log.d(TAG, "...Bluetooth ON...");
  } else {
   //Prompt user to turn on Bluetooth
   Intent enableBtIntent = new Intent(BluetoothAdapter.ACTION_REQUEST_ENABLE);
   startActivityForResult(enableBtIntent, 1);
  }
 }
}

private void errorExit(String title, String message){
 Toast.makeText(getBaseContext(), title + " - " + message, Toast.LENGTH_LONG).show();
 finish();
}

private class ConnectedThread extends Thread {
  private final InputStream mmInStream;
  private final OutputStream mmOutStream;

  public ConnectedThread(BluetoothSocket socket) {
    InputStream tmpIn = null;
    OutputStream tmpOut = null;

    // Get the input and output streams, using temp objects because
    // member streams are final
    try {
       tmpIn = socket.getInputStream();
       tmpOut = socket.getOutputStream();
     } catch (IOException e) { }

     mmInStream = tmpIn;
     mmOutStream = tmpOut;
   }

   public void run() {
     byte[] buffer = new byte[256];  // buffer store for the stream
     int bytes; // bytes returned from read()

     // Keep listening to the InputStream until an exception occurs
     while (true) {
       try {
         // Read from the InputStream
         bytes = mmInStream.read(buffer);        // Get number of bytes and message in "buffer"
         h.obtainMessage(RECIEVE_MESSAGE, bytes, -1, buffer).sendToTarget();     // Send to message
queue Handler
       } catch (IOException e) {
         break;
       }
     }
     }

   public void write(String message) {
     Log.d(TAG, "...Data to send: " + message + "...");
     byte[] msgBuffer = message.getBytes();
     try {
       mmOutStream.write(msgBuffer);
     } catch (IOException e) {
       Log.d(TAG, "...Error data send: " + e.getMessage() + "...");
      }
   }
 }
 private void sendData(String message) {
  byte[] msgBuffer = message.getBytes();
  sent=message;

  Log.d(TAG, "...Send data: " + message + "...");

  try {
   outStream.write(msgBuffer);
  } catch (IOException e) {
      String msg = "In onResume() and an exception occurred during write: " + e.getMessage();
      if (address.equals("00:00:00:00:00:00"))
        msg = msg + ".\n\nUpdate your server address from 00:00:00:00:00:00 to the correct address on
line 35 in the java code";
        msg = msg +  ".\n\nCheck that the SPP UUID: " + MY_UUID.toString() + " exists on server.\n\n";

        errorExit("Fatal Error", msg);
    }
  }
}
```

Arduino Code

```
#include <SoftwareSerial.h>
String readString;
char incomingByte;     // Incoming Data From bluetooth
int RV = 11;           // O = Reversing Valve
int F = 13;            // G = Fan
int Y = 12;            // Y1 = Compresor Stage 1
int t = 1;             // Timer for Test Mode ON/OFF
int DE = 4;            // RS485 Direction control
int m=0;               // Counter for each sent packet
int g=0;               // Counter for ech received byte
byte c;                // Received byte through RS485
byte first, second, third, fourth, fifth, sixth;   // Assigning names to the desired bytes in the packet
word Ser;              // Assigning first and second important byte to a word for displaying purposes
float d;               // Variable to calculate values with one decimal value


void setup() {
 Serial.begin(9600);     // Initialization Serial (For RS485 use)
 Serial1.begin(9600);    // Initialization Serial 1 (For Bluetooth use)
 pinMode(RV, OUTPUT);    // Reversing Valve Pin 11 set as output
 pinMode(F, OUTPUT);     // Fan Pin 13 set as output
 pinMode(Y, OUTPUT);     // Compressor Pin 12 set as output
 pinMode(DE, OUTPUT);    // DE Direction Control Pin (Pin 4) set as output
}

void loop() {

//Control Phase Using Serial 1
   if (Serial1.available() > 0) {    // if there is any data coming from the bluetooth
   incomingByte = Serial1.read();    // read byte



 //Blink Fan 3 times to start Test Mode
 if(incomingByte == 'T'){
   for(t; t < 5; t++) {           // TEST MODE ON
     digitalWrite(F, LOW);        // turn the LED off (LOW is the voltage level)
     delay(1000);                 // wait for a second
     digitalWrite(F, HIGH);       // turn the LED on by making the voltage HIGH
     delay(1000);                 // wait for a second
     }

   if(t=5){
     t=0; //Reset the Test Mode Counter
```

```
    }
   }

 //Blink Fan 3 times to stop Test Mode
 else if(incomingByte == 't'){
  for(t; t < 5; t++) {           // TEST MODE OFF
    digitalWrite(F, HIGH);       // turn the LED on (HIGH is the voltage level)
    delay(1000);                 // wait for a second
    digitalWrite(F, LOW);        // turn the LED off by making the voltage LOW
    delay(1000);                 // wait for a second
    }
  if(t=5){
    t=0; //Reset the Test Mode Counter
    }
   }

 //Starting Cooling Mode
 if(incomingByte == 'C') {                  // COOLING MODE
   digitalWrite(RV, HIGH);                  // REVERSING VALVE HIGH
   digitalWrite(Y, HIGH);                  // COMPRESSOR HIGH
   }

 //Ending Cooling Mode
 else if (incomingByte == 'c'){
   digitalWrite(RV, LOW);                    // REVERSING VALVE LOW
   digitalWrite(Y, LOW);                    // COMPRESSOR LOW
   }

 //Starting Heating Mode
 if(incomingByte == 'H') {                   // HEATING MODE
   digitalWrite(RV, LOW);                    // REVERSING VALVE LOW
   digitalWrite(Y, HIGH);                   // COMPRESSOR HIGH
   }

 //Ending Heating Mode
 else if (incomingByte == 'h'){
   digitalWrite(RV, LOW);                    // REVERSING VALVE LOW
   digitalWrite(Y, LOW);                    // COMPRESSOR LOW
   }



//RS485 Phase using Serial
 if(incomingByte == 'S'){   //Sending package to receive Serial Number
```

```
   digitalWrite(DE, HIGH);
     for (m; m < 1; m++){
        Serial.write(0x30);
            delay(2);
        Serial.write(0x03);
           delay(2);
        Serial.write(0x51);
           delay(2);
        Serial.write(0x1F);
           delay(2);
        Serial.write(0x00);
           delay(2);
        Serial.write(0x01);
           delay(2);
        Serial.write(0xA1);
           delay(2);
        Serial.write(0x11);
           delay(2);
 }
}

 if(incomingByte == 'F'){   //Sending package to receive current and last 5 stored fault codes
   digitalWrite(DE, HIGH);
     for (m; m < 1; m++){
        Serial.write(0x30);
            delay(2);
        Serial.write(0x03);
           delay(2);
        Serial.write(0x51);
           delay(2);
        Serial.write(0x1C);
           delay(2);
        Serial.write(0x00);
           delay(2);
        Serial.write(0x03);
           delay(2);
        Serial.write(0xD0);
           delay(2);
        Serial.write(0xD0);
           delay(2);
 }
}

 if(incomingByte == 'L' || incomingByte == '1'){   //Sending package to receive LT1 Temperature in F
```

```
   digitalWrite(DE, HIGH);
     for (m; m < 1; m++){
        Serial.write(0x30);
            delay(2);
        Serial.write(0x03);
           delay(2);
        Serial.write(0x51);
           delay(2);
        Serial.write(0x20);
           delay(2);
        Serial.write(0x00);
           delay(2);
        Serial.write(0x01);
           delay(2);
        Serial.write(0x91);
           delay(2);
        Serial.write(0x1D);
           delay(2);
 }
}

  if(incomingByte == 'l' || incomingByte == '2'){   //Sending package to receive LT2 Temperature in F
   digitalWrite(DE, HIGH);
     for (m; m < 1; m++){
        Serial.write(0x30);
            delay(2);
        Serial.write(0x03);
           delay(2);
        Serial.write(0x51);
           delay(2);
        Serial.write(0x21);
           delay(2);
        Serial.write(0x00);
           delay(2);
        Serial.write(0x01);
           delay(2);
        Serial.write(0xC0);
           delay(2);
        Serial.write(0xDD);
           delay(2);
 }
}
```

```
   if(incomingByte == 'W' || incomingByte == 'w'){   //Sending package to receive Entering Water
Temperature in F
   digitalWrite(DE, HIGH);
    for (m; m < 1; m++){
      Serial.write(0x30);
         delay(2);
      Serial.write(0x03);
        delay(2);
      Serial.write(0x51);
        delay(2);
      Serial.write(0x23);
        delay(2);
      Serial.write(0x00);
        delay(2);
      Serial.write(0x01);
        delay(2);
      Serial.write(0x61);
        delay(2);
      Serial.write(0x1D);
        delay(2);
  }
 }

   if(incomingByte == 'R' || incomingByte == 'r'){   //Sending package to receive Leaving Water
Temperature in F
   digitalWrite(DE, HIGH);
    for (m; m < 1; m++){
      Serial.write(0x30);
         delay(2);
      Serial.write(0x03);
        delay(2);
      Serial.write(0x51);
        delay(2);
      Serial.write(0x24);
        delay(2);
      Serial.write(0x00);
        delay(2);
      Serial.write(0x01);
        delay(2);
      Serial.write(0xD0);
        delay(2);
      Serial.write(0xDC);
        delay(2);
  }
 }

   if(incomingByte == 'A' || incomingByte == 'a'){   //Sending package to receive Leaving Air Temperature
in F
   digitalWrite(DE, HIGH);
    for (m; m < 1; m++){
      Serial.write(0x30);
         delay(2);
      Serial.write(0x03);
        delay(2);
      Serial.write(0x51);
        delay(2);
      Serial.write(0x25);
        delay(2);
      Serial.write(0x00);
        delay(2);
      Serial.write(0x01);
        delay(2);
      Serial.write(0x81);
        delay(2);
      Serial.write(0x1C);
        delay(2);
  }
 }

   if(incomingByte == 'D' || incomingByte == 'd'){   //Sending package to receive Compressor Discharge
Temperature in F
   digitalWrite(DE, HIGH);
    for (m; m < 1; m++){
      Serial.write(0x30);
         delay(2);
      Serial.write(0x03);
        delay(2);
      Serial.write(0x51);
        delay(2);
      Serial.write(0x27);
        delay(2);
      Serial.write(0x00);
        delay(2);
      Serial.write(0x01);
        delay(2);
      Serial.write(0x20);
        delay(2);
      Serial.write(0xDC);
```

```
            delay(2);
  }
 }

    if(incomingByte == 'E' || incomingByte == 'e'){   //Sending package to receive Entering Hot Water
Temperature in F
    digitalWrite(DE, HIGH);
      for (m; m < 1; m++){
         Serial.write(0x30);
             delay(2);
         Serial.write(0x03);
            delay(2);
         Serial.write(0x51);
            delay(2);
         Serial.write(0x26);
            delay(2);
         Serial.write(0x00);
            delay(2);
         Serial.write(0x01);
            delay(2);
         Serial.write(0x71);
            delay(2);
         Serial.write(0x1C);
            delay(2);
  }
 }

    if(incomingByte == 'G' || incomingByte == 'g'){   //Sending package to receive Target Airflow in CFM
    digitalWrite(DE, HIGH);
      for (m; m < 1; m++){
         Serial.write(0x30);
             delay(2);
         Serial.write(0x03);
            delay(2);
         Serial.write(0x51);
            delay(2);
         Serial.write(0x14);
            delay(2);
         Serial.write(0x00);
            delay(2);
         Serial.write(0x01);
            delay(2);
         Serial.write(0xD0);
            delay(2);
      Serial.write(0xD3);
        delay(2);
 }
}

  if(incomingByte == 'B' || incomingByte == 'b'){   //Sending package to receive Blower Speed in RPM
  digitalWrite(DE, HIGH);
   for (m; m < 1; m++){
      Serial.write(0x30);
         delay(2);
      Serial.write(0x03);
        delay(2);
      Serial.write(0x51);
        delay(2);
      Serial.write(0x28);
        delay(2);
      Serial.write(0x00);
        delay(2);
      Serial.write(0x01);
        delay(2);
      Serial.write(0x10);
        delay(2);
      Serial.write(0xDF);
        delay(2);
 }
}

  if(incomingByte == 'P' || incomingByte == 'p'){   //Sending package to receive Pump Speed in %
  digitalWrite(DE, HIGH);
   for (m; m < 1; m++){
      Serial.write(0x30);
         delay(2);
      Serial.write(0x03);
        delay(2);
      Serial.write(0x51);
        delay(2);
      Serial.write(0x15);
        delay(2);
      Serial.write(0x00);
        delay(2);
      Serial.write(0x01);
        delay(2);
      Serial.write(0x81);
        delay(2);
        Serial.write(0x13);
           delay(2);
 }
}

   if(incomingByte == 'V' || incomingByte == 'v'){   //Sending package to receive Control Voltage in VAC
   digitalWrite(DE, HIGH);
     for (m; m < 1; m++){
        Serial.write(0x30);
            delay(2);
        Serial.write(0x03);
           delay(2);
        Serial.write(0x51);
           delay(2);
        Serial.write(0x2A);
           delay(2);
        Serial.write(0x00);
           delay(2);
        Serial.write(0x01);
           delay(2);
        Serial.write(0xB1);
           delay(2);
        Serial.write(0x1F);
           delay(2);
 }
}

}
 //Receiving Data from the DXM2 Board
 if (m==1){                          // if a packet has been successfully sent & received by the DXM2 Board
   digitalWrite(DE,LOW);               // Enable receive
     if (Serial.available()>0){        // if packet response available
       c=Serial.read();               // read each byte one by one
       readString+=c;                 // set each value to a string
         if(readString.length()>0){    // if readString has a value
           readString="";             // empty string
           g++;                      // increase counter

          //Assigning byte variables to the desired bytes only
             if(g==4){
               first=c;
             }
             if(g==5){
               second=c;
          }
         if(g==6){
           third=c;
          }
         if(g==7){
           fourth=c;
          }
         if(g==8){
           fifth=c;
          }
        if(g==9){
           sixth=c;
          }

      if((g==7 && incomingByte!= 'F') || (g==11 && incomingByte == 'F')){  //This statement only occurs
after all bytes have been received (11 bytes for foult Codes and 7 bytes for the rest)
        Ser= first << 8 | second; //Concatenates the first and second received bytes
        d=Ser/10.0;

          if(incomingByte == 'S'||incomingByte == 'G'||incomingByte == 'g'||incomingByte ==
'B'||incomingByte == 'b'){
             Serial1.println(Ser); //Prints Serial, Target Airflow, Blower Speed
          }

          if(incomingByte == 'F'){
             Serial1.println(first); //Prints current Fault Code only
          }

          if(incomingByte == 'L'||incomingByte == '1'||incomingByte == 'l'||incomingByte ==
'2'||incomingByte == 'W'||incomingByte == 'w'||incomingByte == 'R'||incomingByte ==
'r'||incomingByte == 'A'||incomingByte == 'a'||incomingByte == 'D'||incomingByte ==
'd'||incomingByte == 'E'||incomingByte == 'e'||incomingByte == 'V'||incomingByte == 'v'){
             Serial1.println(d,1); //Prints LT1, LT2, Entering Water Temperature, LEaving Water
Temperature, Leaving Air Temperature, Compressor Discharge Temperature, Entering Hot Water
Temperature, Control Voltage
          }

          if(incomingByte == 'P'||incomingByte == 'p'){
             Serial1.println(second); //Prints Pump Speed
          }


        m=0; //Reset counter m
        g=0; //Reset counter g
```

```
    }
   }
  }
 }

}
```